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THE GOUTY STEM TREE.

(ADANSONIA GREGORII, MUELL.)

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(*With a Coloured Plate.*)

In our last paper on the African species of Adansonia, we stated that the genus mustered only two species, one, as we there showed, a native of Africa, and the other a native of Australia, "A wide geographical difference in habit," our readers will no doubt say. It has been thought by some, that the two species might prove to be identical, and that the slight differences in their leaves, flowers, etc., might be the cause of accident, or some change in nature unknown to us, rather than a specific distinction; but in the general form of the Australian trees there is also some difference. It is known as well by distinct colonial names as by a distinct scientific one. Gouty Stem Tree, in allusion to its peculiar shape; or Cream of Tartar tree, or Sour Gourd, from the acid flavour of the pulp, are its colonial appellations. Cream of Tartar tree is derived from Krem tart boom, the name given by the Boers to the African tree.

The Gouty Stem tree is known to botanists as *Adansonia Gregorii*, which name was given to it by Dr. Ferdinand Mueller, of Melbourne, in honour of Mr. A. C. Gregory, the commander of the expedition sent by the Royal Geographical Society to explore North-West Australia during the years 1855, 1856, and 1857. *Adansonia Gregorii*

is confined to this part of Australia, growing chiefly on the sandy plains and low stony ridges, and extending from the Glenelg River to the western shores of Arnheim's land. Though it is not found exclusively in the vicinity of the sea coast, it seldom occurs more than a hundred miles inland. Many of the explorers into the region of these trees have recorded their surprise and amazement upon first beholding them, yet comparatively little is generally known about them. Captain King, who surveyed the Australian coasts, says in his "Voyage on the Coasts of Australia," "Mr. Cunningham was fortunate in finding the fruit of a tree that was first seen by us at Cambridge Gulf, and had for some time puzzled us from its immense size and peculiar appearance. It proved to be a tree of the natural order Capparidaceæ, and was thought to be a Capparri. The gouty habit of the stem, which was soft and spongy, gave it an appearance of disease; but as all the specimens, from the youngest plant to the full-grown tree, possessed the same deformed character, it was evidently the peculiarity of its habit. The stem of the largest of these trees measured twenty-nine feet in girth, while its height did not exceed twenty-five feet."

If the trees seen by Captain King did not exceed twenty-nine feet in circumference, they were small in comparison with those seen by Gregory's expedition, as we shall presently see. It is not to be wondered that they should hastily have been conjectured to belong to the natural order Capparidaceæ, especially if the trees were leafless at the time, and the members of the expedition had no previous acquaintance with the African species; from the external appearance of the fruit alone one might readily believe it to be a Capparri, and Allan Cunningham first described it as *Capparri gibbosa*. The botanical differences between this tree and its African brother, as we have before hinted, are not very marked. The leaves in this, as in the African species, are digitate, the leaflets entire, acuminate, and when fully grown, from four to five inches long, very slightly pubescent above, and covered with white tomentum beneath. The petals of the flowers, like those of *A. digitata*, are yellowish, or cream white, measuring quite four inches long. The calyx is oblong, entire in the bud, but splits into three or five lobes as the flower opens. The stamens are united into a column, but this column is not so long, neither are the filaments and anthers so densely crowded together in such a spherical mass as they are in the African species. The fruits in the Museum at Kew are not more than six inches long, and three or four inches wide; when ripe they assume a brownish yellow colour, and are covered

with a soft pubescence, from the woody rind or shell a dark red gum exudes.

From the foregoing description it will be seen that in the foliage and flowers of the two species there is a great similitude; the chief points of distinction seem to be that the leaflets are not so broad in the Australian tree as they are in the African; the calyx, also, is not so broad nor so regularly divided, the petals are narrower, and the filaments and anthers not so numerous or arranged together in such a globular tuft; it will also be observed that the fruits in the collection at Kew are smaller, though it is possible they may not be quite fully grown. The woodcut shows a leaf, an expanded flower, a flower-bud, and young fruit.

Dr. Bennett, in his "Gatherings of a Naturalist in Australia," says: "Whether in the valleys, on the borders of rivers, or in the forests, the tree attracts the attention of the traveller by the extraordinary forms it assumes, so unlike in character to other trees constituting the sylvan scenery around, even amid the surprising variety seen in tropical forests. The trunks, resembling gigantic yams, are filled with abundance of mucilage, very similar to gum tragacanth, forming a reservoir of aliment calculated for the climate in which these trees grow. In the valley of St. Trinidad several of them were scattered about, and among them was one particularly

conspicuous, not only from its large size and picturesque irregularity of form, but from its resemblance to the union of three trees in one. Unlike the others we had seen, it was almost entirely destitute of foliage; but this loss was amply compensated by its allowing the peculiar formation of the branches to be seen. This vegetable monster was laden with ripe fruit, pendent from long twisted spongy stalks, that varied in length from one to two feet, and the trunk was forty feet in circumference and sixty feet high; the bark is smooth, of a grayish colour. The termination of its larger stems had a remarkable form, being abruptly rounded; but from these rounded extremities branches were given off, which were out of all relative proportion to the height of the tree."

Both the Adansonias, when denuded of their leaves, and exhibiting more clearly their gaunt bare limbs, form a striking contrast to the evergreen forest vegetation so characteristic of tropical countries; but when in full leaf and flower, the cool green of the former and the delicate creamy white of the latter imparts a most refreshing and luxuriant character to the scene. In September, 1855, the expedition under Mr. Gregory's command entered the Victoria River, in North-West Australia, and while searching for water in the parched ravines, and incited onwards by the distant view of verdant herbage, they saw scattered through the valleys these very singularly formed trees; their great size and the gnarled appearance of their crooked branches made them objects of peculiar interest. At that time the trees were leafless, but the fruits were still pendent from the branches, while many were lying scattered beneath their spreading shade. Upon opening the fruits and tasting the pulp, which had become hard and dry, it was found to have retained its acid flavour; but the travellers were parched and in search of water, and failing in this they discovered that the trunks of the trees were exceedingly fleshy or succulent, and for the sake of the moisture which they contained they cut through the bark and outer portion of new wood, and taking out large pieces, which were more like wet sponge than wood, chewed them to allay their thirst. Though the wood of both species is soft and porous, and both equally useless either for timber or fuel, of the two the African seems to be the hardest, and to contain less sap or fluid matter. The wood of the Australian tree, when cut into chips, was readily devoured by the sheep belonging to the North Australian expedition. In a note from Mr. Baines, he says:—"Mr. Gregory and I went in search of water, and found about a gallon in a cleft, where we could only reach it by fixing the shell of a Gouty Stem

fruit in a cleft stick and lowering it down. Several pandani and Gouty Stems grew below, and one of the latter, about seven feet in diameter, having its outer layers of wood partially destroyed by fire, had fallen over, its soft stem wrinkling upon one side and distending on the other, like a roll of brown paper, without breaking in any part, till its top rested on the ground.

In the Museum at Kew is an oil painting representing a Gouty Stem tree at a station formed by the expedition on the Victoria River. The base of this tree was over thirty feet in circumference, and on the bark was painted, or rather daubed with yellow clay, a series of those grotesque figures of so much interest to the students of picture and gesture language. The figures represented were an emeu and a tortoise, while on other parts of the bark were carved or scratched some of the most grotesque forms. On another tree representations appear of a man, a lizard, and an animal something like a snake, but having horns, and ears, and two legs. At the back of the trees is a low rock, on which also figures have been painted or smeared in red, white, and black. It is not in our province to say, even if we could, what was intended to be conveyed by these singular readings. The figures are well represented in the paintings at Kew. Our readers will doubtless recollect that a notice of an interesting work on gesture language appeared in the INTELLECTUAL OBSERVER for July, 1865, vol. vii., p. 451.

Many of the trees, which appear at first to be gigantic single trunks, dividing above into three or more stout arms, upon a closer examination look suspiciously like a group of individual trees which when young have grown separately, but near each other, and as their circumferences have enlarged have become united, the dividing or radiating above being caused by the force of the continued enlargement. One tree particularly, noticed by Dr. Mueller and Mr. Baines, in latitude 160° 7′ south, longitude 130° 56′ east, consisted of five or six stems which seemed to have united as they enlarged, and at that time formed a solid mass to more than six feet from the ground. Their collective girth was fifty-eight feet.

The group of trees shown in the coloured plate grew near the Baines River, a tributary of the Victoria. The tree on the right hand of the plate had fallen from its upright position in a similar manner to the African trees; the trunks of some actually lie on the ground for a length of ten feet, and then rise into a perfectly upright position, bearing their dense masses of foliage, and flowering and fruiting apparently with as much vigour as their more normally-conditioned neighbours. Like the African tree, the creamy white

flowers first appear, then the young fresh green leaves, and as the flowers pass away and the young fruit forms, the leaves are also passing, till the fruit, matured and drying up preparatory to its fall, hangs amid the scanty remaining foliage. The fruits ripen about April, but they frequently hang upon the trees for some considerable time afterwards; the pulp, which consists of gum, starch, sugary matter, and malic acid, has the same pleasant acid flavour as that of the African Baobab. It is said to be very useful for the cure of scurvy, for which purpose the sailors of the North Australian expedition, when suffering from that disease, used to collect the fruits, and boil the pulp with sugar.

The Adansonias acquire a melancholy interest from the fact of their being chosen as a shelter for the last resting-place of explorers who have been unable to survive the hardships of their journeys, for while Mrs. Livingstone, who may justly lay claim to the title of explorer, is buried under an African Baobab, the carpenter of Mr. Gregory's expedition, who died in 1856, is buried under a Gouty Stem tree, into the bark of which a cross was cut by some members of the expedition.

THE DESATIR, AN ANCIENT RELIGIOUS BOOK OF THE FIRE-WORSHIPPERS.

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THE sacred books of any nation must possess an absorbing interest for all who desire to solve the great problem of human intellectual development. Considered as the direct utterance of inspiration, they influence every action of a people's life, and underlie its entire social and ethical system. But an authority like this must rest on something higher than the pretensions of an individual. Had Mohammed and Zoroaster been the designing impostors that too many suppose them to have been, the religion of the Koran and Zend-Avesta could never have been accepted as the faith of so many millions of the human race. It was not because these men founded new religions that their names have become watchwords in the East, but because they systematized the existing theosophic ideas, and adapted them to the exigencies of the age in which they lived, and of the people amongst whom they dwelt. It is in such books,

then, that we must look for the story of a nation's inner life—for the history of those principles upon which its laws and institutions are based. But if these remarks are true of the Scriptures of nations generally, how much more interest must attach to those of the earliest members of the Aryan race, the progenitors of that great family to which nearly all that is true or noble in the world is due.

The religion of Zoroaster was not a mere superstitious worship of fire, but the philosophical development of certain ethnical ideas, and its details are the natural outcome of that tendency to the observation of physical phenomena which has ever characterised the Aryan race. The Irani shepherd of old, as he gazed upon the hosts of heaven, and construed its myriad lights into so many glimpses of the effulgence of the Deity himself, was but pursuing the same course of investigation which led to the discoveries of Galileo and Newton. And when he advanced a step further, and, deducing from analogy that fire was the source of light, identified this element more or less with the nature of the Deity, he was but following his ethnical and instinctive inclination to natural philosophy. Nay, the same consideration that led him to this conclusion led also the Western philosophers to number fire amongst the primal elements of the material universe.

The earliest and most primitive form of Iranian religion of which any records have come down to us, is the Mahabadian, whose tenets are preserved in the Desatir.

This book is written in a dialect which, though akin to the modern Persian, differs, like that of the Zend-Avesta, from any other known form of Irani speech. It lays claim to the remotest antiquity, and is accompanied by a Persian translation and commentary, purporting to be the production of the fifth Sasan, who lived in the time of Khosrau Parvez, a contemporary of the Roman Emperor Heraclius, and who died in the year 643 of our era. I propose to discuss separately the name, date, and language of this work, to offer a brief analysis of its contents, and, lastly, to consider its value as a historical monument of Aryan theosophic thought.

The correct title of the book is "Vasatir." The copyist seems to have mistaken the *w*, ﻭ, for *d*, ﺩ, and the error to have been perpetuated, in consequence of the conformity of the word *dasatir*, thus formed, with the Arabic plural of *dastúr*, which in Persian signifies a canon or rule. "*Vasatir*" is connected with the Sanscrit root भाष *bhásha* to speak, and means "an oracle."

The *Asmani* or "Celestial" language, in which the Desatir is written, has given rise to many controversies, and some of the most eminent Orientalists have not hesitated to deny altogether the antiquity of the work, and to pronounce the language an impudent forgery of modern times. Later criticism, however, assisted by the recent discoveries in comparative philology, has established the genuine character of the Asmani language, and assigned it a place amongst the most ancient forms of Persic speech. Anthony Troyer, in his preface to the Dabistan, has treated this subject in so masterly a manner, that I need do little more than recapitulate briefly his arguments in favour of the authenticity of the work. These are:—

The improbability of the forgery of a language which comparative philology could not detect.

That if the Desatir had been forged as a rival to the Koran, as many surmise, it must have been written in a national language for a nation.

That the identity of phraseology and construction which exists between the Mahabadi text and the translation which accompanies it, is rather an argument in support of the authenticity of the dialect, as a form of Persian speech, than of its factitious character. Moreover, this identity is constantly aimed at in the translation of important works.

That the existence of roots which seem to belong to the more modern dialects, such as the Hindí, is to be referred to the fact that popular and vulgar dialects often contain remains of ancient tongues: namely, words and locutions which have become obsolete, or disappeared in the cultivated idioms.*

That the structure and syllabic formation of the language, when compared with the modern Deri, display the same relation to it as the Gothic has to the English.

That, moreover, numerous Germanic radicals are found in the Mahabadian language which cannot be attributed to the well-known affinity between the German and modern Persian, because they are no longer to be found in the latter, but solely in the Desatir; but the accidental coincidence of an invented factitious language with Greek, Latin, and Germanic forms would be a greater miracle than the wonderful regularity of this ancient sacred idiom, and its conformity with the modern Deri.

* Thus, the Greek of the New Testament often brings back words and forms of speech which had been disused in the classical language since the time of Herodotus.

If some Arabic words are found in the Desatir, these afford no inference that these works had not been composed before the Arabs conquered Persia, because these words might have come from Pehlevi, in which there is an admixture of Arabic, as relations have subsisted between Persia and Arabia from time immemorial.

These considerations, and other internal evidence, have induced Mr. Troyer to regard the Asmani language "as a new intermediate ring in the hermetic chain which connects the Germanic idioms with the old Asiatic languages; it is, perhaps, the most ancient dialect of the Deri, spoken, if not in Fars, yet in the north-eastern countries of the Persian empire; to wit, in Sogd and Bamian. When it ceased to be spoken, like several other languages of bygone ages, the Mahabadian was preserved perhaps in a single book, or fragment of a book, similar in its solitude to the Hebrew Bible, or the Persian Zend-Avesta."

The Bibliographical history of the book is simply as follows: Although evidently well known to the older Persian writers (by whom it was regarded as the sacred volume of a particular sect), quoted in various works, and cited as an authority for obsolete forms by the author of the most celebrated of Persian dictionaries, it was entirely lost to the literary world until the year 1778, when a Parsee gentleman named Káûs purchased a copy accidentally, under the title of a Guebre book ("Kitábi Gabrí"), at a bookstall in Isfahan. His son, Mollah Firúz, one of the most learned Persian scholars that India has produced, published it at Bombay about forty-five years afterwards.

The Desatir consists of sixteen Books or Prophecies, attributed to the earliest sages and prophets of Iran. The first of them is that of Shet Mahabad, that is, the prophet the great Abad. This name, evidently Sanscrit in its origin, is applied to a dynasty said to have been established in Iran ages before the accession of Kaiomers, the first of Persian historical kings. Mahabad, we are informed by Mohsan Fani, the author of the Dabistan, ruled over the whole earth, and divided the people into four orders—the religious, the military, the commercial, and the servile, to which he assigned names unquestionably the same in their origin with those now applied to the four primary classes of the Hindus. It is said also that he received from the Creator, and promulgated amongst men, a sacred book called the Desatir; and that *fourteen Mahabads* had appeared, or would appear, in human shapes for the government of the world. "When we know," says Sir William Jones, in

commenting on this passage, "that the Hindus believe in fourteen Menus, or celebrated personages with similar functions, the first of whom left a book of regulations or divine ordinances, which they hold equal to the Vedas, and the language of which they believe to be that of the gods, we can hardly doubt that the first corruption of the purest and oldest religion was the system of Indian theology invented by the Brahmin, and prevalent in these territories, where the book of Mahabad or Menu is at this moment the standard of all religious and moral duties."

The book of Mahabad commences with a confession of the existence and unity of God (Mezdám), who is also called Lareng, that is, the Being without qualities:—

"Existence, and Unity, and Identity are inseparable properties of His original substance, and are not adventitious to Him.

"He is without beginning or end. . . .

"He is Living, and Wise, and Powerful, and Independent, and Just, and His Knowledge extends over all that is heard, or seen, or that exists.

"And all existence is visible to His Knowledge at once without time: and from Him nothing is hid."

It is interesting to observe how this idea of the Infinite, which seems to have gone through the whole system of Aryan philosophies, is expressed by one of the greatest thinkers and poets of modern times:—

> "Let there be light, and there was light: 'tis so;
> For was, and is, and will be, are but is;
> For all creation is one act at once,
> The birth of light."*

Then follows an account of the creation of the First Intelligence, or Khirid, through which proceeded the intelligences, and souls, and bodies which make up the system of the heavens; to each division of the heaven, that is, to each sphere, planet, etc., a separate intelligence and soul is assigned. This accords with the cosmogony of the modern Persian philosophy, in which the "Primal Intelligence" is said to have been the channel for communicating God's command for the creation of the universe, and in which also the planets are said to influence mankind through the intelligences which preside over them.

Heaven itself is thus described:—

"Heaven is the abode of the Angels, the city of Souls, and the place of Spheres.

"Whoever approaches the Angels sees the substance of the Lord of the World.

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* Tennyson's "Princess."

"The rapture thence arising no transport of the lower world can equal, the tongue cannot express nor the ear hear, nor the eye see such ecstacy.

"In the heavens there is joy such as none but those who enjoy it can conceive.

"The lowest degree of enjoyment in Heaven is such as is felt by the poorest of men when he receives a gift equal to the whole lower world.

"To the Celestials the bounty of the Most High Mezdâm hath vouchsafed a body which admits not of separation, which doth not wax old, and is susceptible of neither pain nor defilement."

The moon is placed lowest in the scale of heavenly beings, and below this is the position of the elements, from the combinations of which all terrestrial creatures are produced. Everything in nature has its guardian angel, down to the minutest particle of dust or the lightest cloud of mist. This tendency to people the whole vast extent of the universe with intelligent beings is an essentially Aryan idea. The Hindus and Greeks had their Uranian and Chthonian deities, their nymphs, demons, and presiding genii, and the Teutonic races their elves and gnomes; but in all these systems the notion of a power of evil antagonistic to the Creator's will is prevalent. In the Persian system, on the contrary, the universe is considered only as the abode of angels, and every intelligent being, whether real or hypothetical, is the glad and humble servant of God:—

"Among the most resplendent, powerful, and glorious of His servants who are free from inferior bodies and matter, there is none God's enemy or rival, or disobedient, or cast down, or annihilated."

The first ideas of the primitive Irani theosophists having been taken from an observation of the heavenly hosts, it was but natural that their religion, as it became more and more elaborated, should assume the form of a sidereal system. We therefore find that every notion of origin, antiquity, or eternity is referred to the celestial bodies, and time is divided into cycles of extravagant duration, regulated by the revolutions of the known planets and fixed stars. These cycles are fully described in the book of Mahabad and its commentary, and it is with a detailed account of his primitive code of society, couched in the form of commandments, that the rest of the first book of the Desatir is taken up. The spirit of this code may be expressed in a few words; it insists upon the worship and acknowledgment of one true God, on the observation of duty towards one's neighbour, and of a considerate regard for even the brute creation, as sharing equally with mankind in the blessings of the watchful care of Providence.

The second part of the Desatir is the book of the prophet Jai-

âfrâm, who succeeded Abadazar, the last of the Mahabadis. Of him the commentator says—

"Abadarad (Abadazar), the last Prince of the Abadians, having found mankind bent on evil, resigned the government, and went into retirement; and so effectually did he escape the observation of men, that no one knows where he went. In consequence of his abdication, the world fell into confusion, and the works of the preceding kings were destroyed. Then the good men went to Jaiâfrâm, the son of Abadarad, who was a recluse like his father, and who, from his fondness for retirement, always lived remote from mankind, and incessantly occupied with the worship of the Deity, and required him to assume the sovereignty, which, however, he declined, until the illustrious book came down to him."

The book of Jaiâfrâm does little more than insist on a proper comprehension of the Divine mysteries contained in the preceding one. It is chiefly remarkable for a beautiful liturgic list of the attributes of God, of which I cannot refrain from quoting a part:—

"The necessarily existent! Light of Lights! Lord of Lords! The Exalted! Of wonderful praise! Of supreme splendour! Of splendid brightness! The blessed giver! Of high purity! The Lord of brightness! The universal Creator! First of the first! Providence of Providences! God of intelligences! Lord of souls! The independent of the independent."

The book of Shet Shikaliv, which follows next, seems to aim at establishing the doctrine of the *exalted* nature of God, and of protesting against the idea of dualism and the anthropomorphic corruption that was already stealing into the Mahabadian creed:—

"That man is a perverter of truth who imagineth that likeness, or quantity, or locality, or body, or any accident among accidents, or any property among properties, can be predicated of Thee;

"Save from necessity, or as a form of speech, or for the purpose of intimation."

In the book of Shet Yasan, the next in the list, we see the tendency towards fire worship gradually developing itself, together with certain directions for ablutions and other ceremonial observances, which indicate the presence of an Indian or Vedantic influence. The worshipper is, however, warned not to confound the reverence due to the elements by which the Deity is symbolized with the Deity himself:—

"Reverence the four Elements, yet do not therefore lay thyself under restraint."

The two next books, those of Gilshah and Siamek, display rather more of the spirit of asceticism and contemplative speculation than is observable in the preceding writings. The language,

too, in which it is expressed, is that of a sect of mystics or illuminati, protesting against the increasing corruption of the primitive faith. This protest finds more full utterance in the book of the prophet Hosheng, called Sed Wakhshur, or "the Hundred-Prophet." Hosheng is universally regarded as the founder of the religion which bears his name; but he was in reality merely the restorer of the simplicity of the primæval faith.

The tenets of the Hoshengis, as they are described in the Dabistan, differ little from the Mahabadian doctrines of the Desatir. These doctrines continued to be professed as an esoteric faith in Iran for many ages. The author of the Dabistan informs us that when Alexander arrived in Persia he found a sect existing there called Gushaspis who claimed Hosheng as their founder, and who, though openly professing the religion of Zoroaster, preserved the tenets taught by Hosheng as the esoteric doctrine of Pyrolatry. The book of Hosheng in the Desatir is full of denunciations, evidently levelled against those who had formed gross conceptions of the Deity, and contains frequent prayers for spiritual illumination:—

"I pray . . . . that He would make me one of those who approach near unto Him, and of the Band of His Lights, and of the company of those who are admitted into the secrets of His essence!"

The books of Tahmuras and Jemshid differ little from those of Hosheng, save that they insist more on the importance of the sun as the source of light, and, as such, entitled to adoration. That of Jemshid contains a curious disquisition upon the personal individuality of the world, and the harmony of all its parts:—

"I created the world an individual," says the text of the Desatir, and the commentator proceeds to explain this statement as follows:—"For the whole world is an individual. Its body, which is composed of all bodies, is called the Universe (Tehîm); its soul, which consists of all souls, is called the City of Souls (Rewângird); and its intelligence is composed of all the intelligences, and is called the City of Understanding (Hoshgird). This is the Great Man. When you have contemplated this World so wonderful, it is but one of His worshippers. If you open the eye of your heart you will perceive that the Heaven is the skin of this Great Individual; Kaiwán (Saturn), the spleen; Barjish (Jupiter), the liver; Behrám (Mars), the gall; the Sun, the heart; Nahid (Venus), the stomach; Tir (Mercury), the brain; and so on. The air is his

breath; the water his sweat; the earth the place on which he steps; the thunder his voice; the lightning his laugh; the rain his tears."

There is a traditional saying of Mohammed, in which this same notion lurks, and which affords a good instance of the way in which Persian ideas were preserved in the semi-Sabæan legends of the ante-Islamitic Arabs. It is related that the prophet, when he saw the lightning and heard the thunder, was wont to say, "Oh, God, destroy us not in thy wrath, but (if Thou wilt), pardon us ere thou doest so. The thunder is the voice of an angel heard in the clouds, and the lightning his laughter; and when his anger is severe, then fire issueth forth from his mouth, and that causeth the thunderbolts."

In both the books of Tahmuras and Jemshid the wickedness and increasing depravity of mankind is deplored, and punishment threatened. Similarly, the books of Faridun, Menuchehr, Kai Khosrau, and Zertusht (Zoroaster), contain no fresh ideas; but it is worthy of remark, that in the one ascribed to Zoroaster the revelation made to that prophet is said to be strictly identical with the faith delivered to Mahabad:—

"Unto whomsoever I grant the gift of prophecy while waking, to him do I deliver the religion of the Great Abad. This religion is My Beloved."

The commentary on this part of the Desatir contains the following interesting anecdote of Zoroaster:—"When the fame of the excellence of Zertusht had spread over all the world, and when Isfendiar went round the world, erected the temples, and raised domes over the fires, the wise men of Yunán (Greece) selected a sage named Tutianush, who in that time had the superiority in acquirements over them all, to go to Iran, and inquire of Zertusht concerning the real nature of things. If he was puzzled and unable to answer, he could be no real prophet; but if he returned an answer, he was a speaker of truth. When the Yunáni sage arrived at Balkh, Gushtasp appointed a proper day on which the Mobeds of every country should assemble, and a golden chair was placed for the Yunáni sage. Then the Beloved of Yezdán (God), the prophet Zertusht, advanced into the midst of the assembly. The Yunáni sage, on seeing that chief, said, 'This form and this gait cannot lie, and nought but truth can proceed from them.' He then asked the day of the prophet's nativity. The prophet of God told it. He said, 'On such a day, and under such a fortunate star, a deceiver cannot be born.' He next inquired into his diet

and mode of life. The prophet explained the whole. The sage said, 'This mode of life cannot suit an impostor.' The prophet of Yezdán then said to him, 'I have answered the questions which you have put to me. Now retain in your mind what the famed Yunáni sages directed you to inquire of Zertusht, and disclose it not, but listen, and hear what they ask; for God hath informed me of it, and hath sent his word unto me to unfold it.' The sage said, 'Speak.' Thereupon Zertusht the prophet ordered his scholar to repeat some texts of the Desatir, which form an answer to the inquiries which Tutianush had been sent to make."

The remaining books are, that entitled the Book of Instructions to Alexander, and those of Shet Sasan the First and Shet Sasan the Fifth. In the first-mentioned writing Alexander is made out to have been the son of Darab, and grandson of Behman, and is said to have been miraculously transported from Persia to Greece, to become the instrument of retaliation upon the Iranis for his father's murder. In this book the first Sasan is predicted as the one who shall make known the contents of the Desatir through a translation and commentary. The fifth Sasan, to whom we owe the present commentary that accompanies the Desatir, and whose book concludes the Desatir, was evidently a thorough enthusiast in the cause of the Mahabadi faith, and it is curious to notice that his enthusiasm led him into a delusion similar to that which seems to have influenced certain visionaries in modern times—I mean, the idea of physical elevation, and actual intercourse with the spiritual world:—

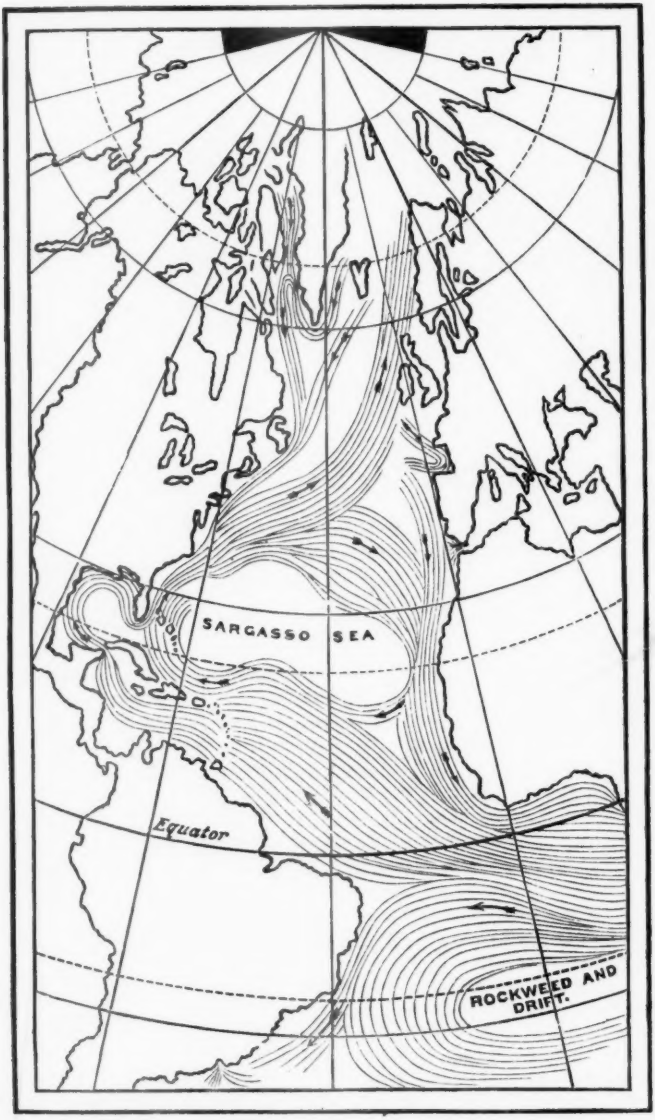
"At the time when Yezdán sent this his humble adorer to Merv, in the time of Parvez, my respected father received this revelation from the world above, and the grandees and the King of Kings also saw it in a dream, and, coming in a body, attached themselves to my sect. And the Most Just elevated me aloft so many times that I cannot reckon them, and these elevations are still continued. And I beheld the place of bodies like a drop in the ocean of souls; and I saw the place of souls like a drop in the place of intelligences, and the place of intelligences like a drop in the ocean of the Divine Essence."

It is impossible to decide who the author of the Mahabadi text really was, or to what age it belongs. The gradual development of religious ideas mentioned in the preceding analysis would seem to show that a considerable time elapsed between the composition of the several parts of the Desatir. The latter portions of the work are full of historical allusions and prophecies after the event, that

must be regarded as interpolations of more modern times, a corruption from which the Vedas themselves are not free. For example, the two last books of the Desatir contain prophecies of the dissensions in the Abbasside and Ali families, of the adoption of Islam by the greater part of the Eastern nations, and of the rise of the Tatar and Turcoman powers. But these considerations do not outweigh the great mass of internal evidence in favour of the antiquity and authenticity of the book, and especially of the part attributed to Mahabad himself, which probably formed the nucleus of the entire work. It affords a most interesting monument of the rise and progress of Persian religious ideas, and contains, on the lowest supposition, the traditional account of the most primitive religion of the East. It is the expression of the earliest yearnings of the Aryan mind after truth—the dreamy enthusiasm of one who believed that he had fathomed the secrets of Heaven itself, that—

"The great Intelligences fair,
That range above our mortal state,
In circle round the blessed gate,
Received and gave him welcome there;

"And led him thro' the blissful climes,
And showed him in the fountain fresh
All knowledge that the sons of flesh
Shall gather in the cycled times."



Isographic Chart of the Atlantic Ocean, showing the Course of the Gulf Stream, etc.

THE GULF STREAM.

BY RICHARD A. PROCTOR, B.A., F.R.A.S.

(*With a Map.*)

MAJOR RENNELL was the first, I believe, to whom we owe the comparison of ocean-currents to rivers. He spoke of them as ocean-rivers, and pointed out how enormously their dimensions exceed those of such streams even as the Amazon and the Mississippi. Some of the ocean-currents are from 50 to 250 miles in breadth, and flow more swiftly than the largest navigable rivers. The banks and bottom of these currents are not land, but water; and so deep are the currents that they are turned aside by shoals and banks whose tops are "40, 50, or even 100 fathoms beneath the surface of the ocean." The outlines of ocean-currents are sharply defined, insomuch that "often," says Captain Maury, "one half of a vessel may be seen floating in the current, while the other half is in common water of the sea." The border-line of the Gulf Stream can be traced by the eye. Yet more remarkable is the distinction between the moving water and that which is at rest, when large masses of sea-weed carried along by the former enable one to recognize the rapidity with which it moves.

Of all the ocean-currents the most important, perhaps, in its bearing on the destinies of men and nations, is the great Gulf Stream. I propose to examine the course and latitudes of this current, and then to inquire a little into the vexed question of its cause.

Major Rennell traced the Gulf Stream from a supposed source in the Indian and Southern Oceans. Modern geographers and physicists prefer to look for the rise of the current somewhere near the Cape of Good Hope. "The commencement and first impulse of the mighty Gulf Stream is to be sought," writes Humboldt, "southward of the Cape of Good Hope." It appears to me, however, that the true source of the great stream is to be looked for in the equatorial zone of the Atlantic. When we come to inquire into the cause or causes which give birth to the Gulf Stream, we are led, as I imagine, to this region rather than to any other (though, perhaps, in a stream which forms part of a continuous system of circulation, we can hardly speak of any one portion as the source); I shall therefore trace the stream, and the system to which it belongs, from the great equatorial waters which move, as Columbus was the first

to discover, "with the heavens (*las aguas van con los cielos*), that is, from east to west, following in this the apparent motions of the sun, moon, and stars."

The accompanying map of the Atlantic Ocean is constructed upon one of those forms of isographic projection considered in my paper on such projections ("Intellectual Observer" for July, 1866). It is important, in dealing with the subject of currents, that the question of area should be considered, and, therefore, that our illustrative charts should represent such areas correctly. This Mercator's charts are far from doing. The portion of the Atlantic Ocean between England and the United States of America is unduly magnified, and still more is this the case with the portion between Sweden and Greenland. On the other hand the portion between Africa and the Gulf of Mexico is unduly diminished. Thus it is scarcely possible to form just notions from such charts of the actual character of the oceanic circulation whereof the Gulf Stream forms a part.

We see, in our map, that there is a great equatorial stream extending in its eastern portion far to the south of the equator, but passing to the north also even here, and still further to the north between the coasts of Africa and South America. Near here the great equatorial current divides into two portions. One passes southward, and then returns towards the east according to some authorities, but, according to others, continues its course southward until it is lost in the Antarctic Ocean. We shall follow the northern bifurcation, however. The course of this portion of the Atlantic current-system has been far more exactly traced out. Taking a north-westerly course, the great current pours itself against the barrier formed by the Leeward and Windward Islands. Passing between these islands, it sweeps around the shores of the Gulf of Mexico, a portion, however, of its volume passing probably outside the West Indian Islands, to rejoin the other outside the promontory of Florida. At this point the stream has become, probably, somewhat diminished in volume, but being still more diminished in breadth, it flows as a deep, strong, and swift stream, known among sailors as "The Narrows of Bemini." From hence the stream, now become the true Gulf Stream, grows gradually wider, less deep, and less swift. Off Hatteras it is already twice as broad as in the Florida Straits, and as it stretches with a wide easterly sweep across the Atlantic towards the shores of Ireland and the Hebrides, the current not only reassumes something of its original extent of surface, but again bifurcates; a wide but somewhat sluggish stream

is sent southward towards the shores of north-western Africa, to rejoin the equatorial stream. The main portion of the current, however, passes with a north-easterly course up the Atlantic valley, between Iceland and Sweden to the Polar seas. It seems uncertain whether Rennell's current, which passes around the Bay of Biscay, and the current which streams southward past the shores of Spain, are forks of the Gulf Stream. They are usually represented in maps as independent currents, and in Captain Maury's large map of the Gulf Stream the great southern bifurcation, already mentioned, is represented as a current impinging upon the flank of the stream which flows past Spain and north-western Africa. Yet, if these streams have not their source in the Gulf Stream, it will be found no easy problem to assign their origin; and I cannot but think that the Biscay and Guinea currents, as well as the current which flows into the Mediterranean through the Straits of Gibraltar, are as truly bifurcations of the Gulf Stream as the current which laves the shores of Ireland and Sweden.

There will be noticed also in the map three return streams, one flowing southward outside Iceland, another sweeping round the eastern shores of Greenland, and the third flowing through Baffin's Bay and Davis's Straits. The two last unite south of Davis's Straits, and flow on together to meet the first stream outside Newfoundland, whence the three flow as a single current past the shores of the United States. It is generally assumed, and in all probability justly, that these three streams are derived from the Gulf Stream, and are different branches of its returning waters.

Between the single return-stream which laves the shores of the United States and the Gulf Stream there is an unshaded space in the map. It is not to be inferred, however, that this space represents still (or rather unflowing) water. On the contrary, it is the "debateable ground" between the opposite currents. In spring the whole of this space is occupied by the southward-flowing waters of the cold return current. In autumn the whole of the space is occupied with the waters of the Gulf Stream. Backwards and forwards over this space the rival currents are continually swaying, the period of an oscillation being one year.

In the widest part of the Atlantic Ocean, that, namely, which extends between the most westerly part of Africa and the West Indies, there is a wide expanse of waters unmoved by the flux or reflux of currents. Surrounded on every side by the circulating waters of the Central Atlantic current-system, this region remains undisturbed save by winds and the tidal wave. Accordingly its

surface is covered with different forms of marine vegetation. My readers will doubtless remember the interest which the Great Sargasso Sea excited in the mind of Christopher Columbus. Oviedo termed this region the "seaweed meadow." "A host of small marine animals," says Humboldt, "inhabit this ever-verdant mass of *Fucus natans*, one of the most widely diffused of the social plants of the ocean, constantly drifted hither and thither by the tepid winds that blow across its surface."

In the South Atlantic there is a smaller and somewhat more sharply defined Sargasso, covered chiefly with rockweed and drift. A weedy space occurs also about the Falkland Islands, but is probably not a true Sargasso. Maury considers that the seaweed reported there probably comes from the Straits of Magellan, where it grows so thickly that steamers find great difficulty in making their way through it. It so encumbers their paddles as to make frequent stoppages necessary.

Such is the distribution of the surface of the Atlantic Ocean. But now the question will at once suggest itself: Is the complete system of oceanic circulation exhibited on the surface? It seems now quite certain that this question must be answered in the negative. We might, indeed, at once point to the existence of the important current which laves the shores of the United States as an answer to the question; for where can all this water find an outlet? It does not pass the Peninsula of Florida as a current; it does not cross the Gulf Stream; where then can it go but underneath the ocean's surface? But we have positive evidence of the existence of under-currents.

In the first place it is found that in deep-sea soundings in many parts of the ocean, far more line may be paid out without any sign of the bottom being reached than the depth of the ocean in those parts would account for. In places where it has been proved by other methods than ordinary sounding that the depth is not more than three miles, no less than ten miles of line have been paid out, being carried out so strongly that the slightest check in the paying-out apparatus has sufficed to break the sounding-line.

In the second place, it has been found possible to determine the depth at which a submarine current is flowing, and the direction in which it flows. Thus Lieuts. Walsh and Lee, in the American service, having loaded a block of wood to sinking, and let it down to different depths, had repeatedly the satisfaction of seeing the work of under-currents. "It was wonderful, indeed," they write, "to see the *barrega*" (a float attached to the upper end of the

line) "moving off, against wind, sea, and surface current at the rate of over one knot an hour, as was generally the case, and on one occasion, as much as one and three quarter knots. The men in the boat could not repress exclamations of surprise, for it really appeared as if some monster of the deep had hold of the weight below, and was walking off with it."

Lastly, we may mention that Captain Wilkes, of the United States Exploring Expedition (and later of Trent notoriety), established the existence of a cold under-current no less than two hundred miles broad at the equator.

We may assume, then, that a complete system of circulation, vertical as well as horizontal, exists throughout the whole of the waters contained within the great Atlantic valley.

Where are we to look for the origin of this vast series of movements? The actual "work done" in the Atlantic Ocean is so enormous—in other words, the transfer of such large volumes of water represents so enormous a *force*, that we might well expect to be able at once to assign the motive-power of this great machinery. For it would seem that the giant which works such wonders could not readily hide himself from our recognition.

It has not been found, however, that the solution of the problem has been so simple as was to have been anticipated.

Passing over the earlier guesses which marked the Gulf Stream as the offspring of the Mississippi River, of the sun's motion in the ecliptic (a mysterious interpretation of the phenomena), and of the tidal wave, we may remark that but two explanations of the Atlantic currents seem to merit discussion.

Sir John Herschel is the principal exponent of the first theory, which assigns to the trade-winds the principal—almost the sole—agency in the generation of the Atlantic current-system. He refuses indeed, to look on the subject as one of any doubt or difficulty. "The dynamics of the Gulf Stream have of late," he writes, "been made a subject of much (we cannot but think misplaced) wonder, as if there could be any possible ground for doubting that it owes its origin *entirely* to the trade-winds." "If there were no atmosphere, there would be no Gulf Stream, or any other considerable oceanic current (as distinguished from a mere surface-drift) whatever." He presents his solution somewhat as follows:—The trade-winds are an actually existent cause for an easterly motion in the tropical seas; we cannot ignore their action; we know, also, that when the trade-winds arrive at the equator, they have lost their easterly momentum; and we know, therefore, that that momentum

must have been imparted to the surface of the water (for where else can it have gone?); hence there arises the great easterly movement which generates the whole system of circulation.

The second view, which attributes oceanic circulation to differences of temperature and saltness in different parts of the ocean, is supported by Humboldt and others, but is taken up most unflinchingly by Captain Maury, who assigns it as practically the sole cause of all oceanic circulation. "The Gulf Stream," he writes, "as well as all the *constant* currents of the sea, is due mainly to this cause. Such differences are inconsistent with aqueous equilibrium, and to maintain this equilibrium the great currents are set in motion. The agents which derange equilibrium in the waters of the sea, by altering specific gravity, reach from the equator to the poles, and in their operations they are as ceaseless as heat and cold; consequently, they call for a system of perpetual currents to undo their perpetual work." "Other causes *help* to cause currents," he says, "but the currents created by them are *ephemeral*."

Here we have what is "a very pretty quarrel as it stands." Each of the disputants points to causes of acknowledged importance, and also (whether efficient or not in the particular respect under question) of acknowledged general efficiency. Each has much to say in favour of his own view, and each considers his antagonist's agent as utterly insufficient for the work ascribed to it. Each has heard his opponent's arguments, and reiterates his own statement. Nor can it be said that the opponents are unequally matched; for, if we must place Sir John Herschel far before Maury as a mathematician and physicist, and if we must undoubtedly look upon the former as the more practised reasoner, yet we must remember, in turn, the special attention which Captain Maury has given to the subject under discussion, and the practical acquaintance with it which his experience as a seaman has given to him.

Let us briefly state the arguments adduced by Herschel against Maury's view, and by Maury against Herschel's.

Sir John Herschel asserts that, inasmuch as the sun's heat warms the *surface* of the ocean most intensely, so that the water of least specific gravity is already uppermost, there can be no tendency to motion. For the heated water cannot *descend*, being buoyant; nor *ascend*, being uppermost; nor move *laterally*, having no impulse to motion of that sort, and being only able to move laterally "by reason of a general declivity of surface, the dilated portion occupying a higher level." He then applies to this declivity the test of quantitative analysis. Taking a column of water at the equator

having at the base a temperature of 39° (at which temperature fresh water attains its greatest density, and which is also the temperature of water 7200 feet beneath the surface at the equator), while its top has a temperature of 84° (the warmth of equatorial surface-water), he finds that such a column is 10 feet higher than a similar column in latitude 56°, where 39° is the surface temperature. And since from the equator to latitude 56° the distance is 3360 geographical miles, we have a declivity of barely one-twenty-eighth of an inch per geographical, or one-thirty-second of an inch per statute mile. Such a declivity is utterly insufficient to account for the existence of a strong current from the equator towards the tropics; while, so far from giving any account of the motion of the equatorial current from east to west, it would tend to form a north-easterly current.

This seems strongly opposed to Maury's view, and I do not find that he does much to get over the force of Herschel's reasoning. He points out, indeed, that sea-water does not attain its greatest density at a temperature of 39°, but some 12° or 14° lower. This, however, does not affect Herschel's argument. If he had taken a column whose base had a temperature of 25° instead of 39°, he would have had to extend, also, the range of the water-slope in latitude; and, in fact, he would have obtained a yet smaller declivity in this way than that actually deduced by him. Maury does not seem to have noticed the really weak point in Sir John's argument. I shall presently show where this seems to me to lie.

But if Maury fails in efficiently defending his own views, he certainly is sufficiently effective in his attack upon Sir John Herschel's.

He asks, in the first place, the pertinent question—How can the north-easterly trade-winds, which blow only 240 days out of 365, cause the equatorial current to flow all through the year towards the north-west, without varying its velocity either to the force or to the prevalence of the trade-winds? "That the winds do make currents in the sea, no one," he says, "will have the hardihood to deny; but currents that are born of the winds are as unstable as the winds; uncertain as to time, place, and direction, they are sporadic and ephemeral."

He then points to a fact which "militates strongly against the vast current-begetting power that has been given by theory to the gentle trade-winds. In both oceans, the Sargasso seas lie partly within the trade-wind region; but in neither do these winds give rise to any current. The weeds are partly out of water, and the wind has therefore more power upon them than it has upon the

water itself; they tail to the wind. And if the supreme power over the currents of the sea reside in the winds, as Herschel would have it, then of all places in the trade-wind region, we should here have the strongest currents. Had there been currents here, these weeds would have been borne away long ago; but so far from it, we know that they have been in the Sargasso Sea of the Atlantic since the voyage of Columbus."

In another argument, Maury certainly falls into an error. He says, How can the north-easterly winds cause the Gulf Stream to flow *towards* the north-east? But, as he himself points out, the trade-winds do not blow over the Gulf Stream proper, and there can be no doubt that, if the trade-winds sufficed to keep up a continual equatorial current, finding a passage towards the north after encountering the barrier opposed by the American continent, this resulting northerly current would assume a north-easterly course, for the very same reason that the air-currents, flowing from the equator towards the north pole, become south-westerly or counter trade-winds. But he seems justified in asking how it is possible that the impulse imparted by the gentle trade-winds to the equatorial current could suffice to generate a stream which eventually travels far towards the north pole, if it do not even circle completely around Greenland. "When we inject water into a pool," he says, "be the force never so great, the jet is soon overcome, broken up, and made to disappear. In this illustration, the Gulf Stream may be likened to the jet, and the Atlantic to the pool. We remember to have observed, as children, how soon the mill-tail loses its current in the pool below; or we may now see at any time, and on a larger scale, how soon the Niagara, current and all, is swallowed up in the lake below."

Franklin, who was the originator of the theory supported by Herschel, had unnecessarily introduced the supposition that the trade-winds maintain a "head of water" in the Gulf of Mexico, and that the Gulf Stream flows downwards like a river from this "head," as a fountain or source. Maury rightly attacks this view, which is undoubtedly a mistaken one; but in doing so, he falls into an error which exhibits his weakness in the treatment of hydrodynamical problems. He points out that, inasmuch as the Gulf Stream grows wider as it crosses the Atlantic, it necessarily grows shallower, so that the water-bed in which the stream flows has a higher level under the shallow than under the deep part of the current, and therefore, says Maury, "*the current runs up hill.*" Herschel terms this a strange perversion of language, but perhaps

it would be more correct to speak of it as a strange blunder. The stream could, of course, only be said to run up hill if *its surface* were seeking a higher level, which does not and cannot happen. That the spreading out of the water of the current, so as to form a wider and shallower stream, does not correspond to an upward flow, is evident from this, that it happens often with rivers, which no one will suspect of *running up hill*.

Herschel does not find an answer to the main objections urged by Maury against the trade-wind theory. Content with urging an apparently unanswerable objection against his opponent's view, he leaves his own to take care of itself.

In forming an opinion respecting the two theories, one is struck with the immense superiority in the *power* of Maury's agent. For, if we consider, we shall see that almost *the whole of the sun's action upon the ocean* goes to produce those variations in temperature and saltness in which Maury sees the origin of the current-system; but a very moderate portion of the sun's action is called into play in the production of the trade-winds. Now it is very doubtful whether any large proportion even of the force expended in producing the trade-winds, ever acts on the water. For we know that the north-easterly and south-easterly air-currents of the northern and southern hemispheres, do not wholly merge into northern and southern currents meeting point-blank near the equator, as Herschel's theory seems to imply. On the contrary, there is a wide zone of calms at the equator, and the two systems of trade-winds appear to pass upwards above the calm air, without parting with the whole of their easterly motion. When once they begin to travel polewards, they lose their easterly motion in the same way that they acquired it—that is, through the effects of the earth's rotation. And whatever portion is lost in this way—which, for aught we know, may be a very considerable portion, cannot be taken into account as available to generate the easterly equatorial current.

And now let us consider for a moment the relation which holds between cause and effect in the case supposed by Herschel. We have more than a fourth part of the Atlantic Ocean in a state of perpetual motion, and it is assumed that the air immediately above the ocean is responsible for this circulation. Now even if we suppose that the whole of the *vis viva* in the aërial circulation is imparted to the waters, and neglect all consideration of the fact that for a large portion of the year the winds do not act in the manner available for the production of the currents we are considering, yet even

then, I apprehend that we shall find the *vis viva* of the aërial very far below that of the aqueous circulation. The volume of moving water is, of course, far less than that of the moving air, and the mean velocity of the water-currents is less than that of the air-currents; but on the other hand, the specific gravity of water is some 830 or 840 times greater than that of air, and this difference far more than counterbalances the others.

But now when we come to consider the forces called into action in producing changes of temperature, etc., we no longer find such a disproportion between cause and effect. The sun's action on the equatorial and tropical regions of the Atlantic not only produces a great change in the density of the water, but also raises immense masses by evaporation. Now the buoyancy caused by increase of temperature is partly diminished through increase of saltness, still it is an important motive-force. A large portion of the evaporated water is also precipitated over the equatorial regions in the form of rain; yet that a very large portion is carried away from equatorial and tropical to temperate zones is beyond dispute.

But now, how are we to get over the arguments by which Herschel seeks to show that the buoyant water will not rapidly move off, and that the effect of evaporation is merely to produce opposing inrushes of water which destroy each other's effect? Easily, I take it, if we remember that the buoyancy of the water *does* produce a surface-flow from the equator, however slight, and that this is sufficient to destroy the balance of forces which might otherwise make it doubtful whether the place of the evaporated water would be supplied from below or from above. I apprehend that there is a continual under-flow of cooler water, rushing in towards the equator on both sides, to supply the place of the water evaporated by the sun's heat. Now there can be no question that under-currents arriving in this manner, whether from the north or from the south, would acquire a strong westerly motion (just as the trade-winds do). Thus they would generate *from below* the great equatorial westerly current. In this up-flow of cool currents having a strong westerly motion, I find the mainspring of the series of motions. The water thus pouring in towards the equator is withdrawn from beneath the temperate and arctic zones, so that room is continually being made for that north-easterly surface-stream which is the necessary consequence of the continual flow of the great western equatorial current against the barrier formed by the American continent.

It would require much more space than I have at my disposal to

deal at length with the subject of my paper. I therefore conclude by referring my readers to Maury's interesting work on the "Physical Geography of the Sea," with the remark that his views seem to me only to require the mainspring or starting force towards the west which I have ventured to suggest, to supply a complete, efficient, and natural explanation of the whole series of phenomena presented by the great ocean-currents.

ON THE ZOETROPE AND ITS ANTECEDENTS.

BY WILLIAM B. CARPENTER, M.D.,

Vice-President of the Royal Society.

It is not generally known even among scientific men, still less to the general public, that it was the fertile brain of Professor Faraday which furnished the original *idea*, whose subsequent development in other hands has given rise to a whole class of remarkable effects—commonly called *optical*, but partly (as will hereafter be shown *mental*)—which are interesting alike to the philosopher and the mere wonder-seeker, to the educated and to the uneducated, to the old and to the young. Of the instruments through which these effects are produced, the *Zoetrope* is the latest, and in many respects the best; especially because its effects may be witnessed by almost any number of persons at a time, without requiring any cumbrous apparatus for their display. But it is not *in principle* at all in advance of the *Phenakisticope* and *Stroboscope*, the invention of which followed almost immediately upon the publication of Professor Faraday's observations, and which were introduced into this country from the Continent more than a third of a century ago.

As the writer well remembers the interest excited in his own mind by the publication in 1831 of Professor Faraday's paper,* "On a peculiar class of Optical Illusions,"—having still by him the apparatus which he constructed at the time to repeat and extend Professor Faraday's experiments,—and as he has since followed with like interest the subsequent developments of that great philosopher's "idea," he has thought it a not inappropriate time to recall that idea to general attention; and to endeavour to explain to those who have recently had their wondering attention drawn to the curious phenomena exhibited by the Zoetrope, the principles on

* "Journal of the Royal Institution," vol. i., p. 205.

which its effects depend. He proposes in a future paper to bring before his readers some of the more remarkable of those less known developments, which the same principles have received under the scientific treatment of Professor Plateau of Liège; whose first inquiries on this subject, which were yet earlier than those of Professor Faraday, had led him to the invention of that very curious instrument the *Anorthoscope* (which is but little known in this country) as far back as 1836.

The first of these principles is that of the *persistence of a visual impression for a determinate interval*, after the object which made it has been withdrawn, or has changed its place.* Of this general fact we have an illustration in the luminous "tail" left by a rocket or of a shooting-star; and in the experiment, which every child knows how to make, of the production of a fiery circle by whirling round a lighted stick in the dark. For in each of these instances, the trail of light which seems to be left behind the luminous object in motion marks the continuance of the visual impression made by it, after its actual image has quitted one part of the retina for another; and the length of that trail increases in proportion to the rate of movement of the object. Hence the child's experiment, if performed with scientific precision, may be made to give a measure of the duration of the impression; for it will be at once seen, that if the luminous point be made to revolve with just sufficient rapidity to complete the luminous trail into a complete circle, the time occupied by a single revolution is that of the persistence of the impression left at any one spot, until it becomes continuous with the new impression made by the return of the object to the same spot. This interval is usually stated to be about one-seventh or one-eighth of a second; but the writer has reason to believe, from experiments

* It is commonly said that "the image remains on the retina;" but this is manifestly incorrect, since the image cannot remain after the withdrawal of the object which caused it. It would be less objectionable to say that "the impression produced by the image remains upon the retina after the image itself has departed:" and this, the writer believes, is the ordinary scientific representation on the subject. It is open to question, however, whether it is a true account of the fact. There is no doubt that a prolonged gaze at a luminous object *does* produce an impression upon the retina, which persists for some time afterwards, manifesting itself in the *spectrum* of the object which is seen when the eyes are closed, or are directed elsewhere. But the persistence of a mode of organic action which has been kept up in a certain part of the retina for an appreciable time, is very different from the persistence of an impression caused by an image of which the duration may not have been more than one millionth of a second; and the writer is disposed to regard this last as rather a *mental* than a *retinal* phenomenon. At any rate, it is better to use language which expresses the *fact* independently of *theory*.

which he formerly made, that it varies in different individuals, and in the same individual under different circumstances,—a more rapid revolution being required when the visual impression is faint, than when it is vivid; the latter, as might be anticipated, enduring longer than the former, so as to produce a continuous circle by a slower movement.

This principle has been applied in various scientific toys, of which one of the earliest was the *Thaumatrope* of Dr. Wollaston. This consists merely of a circular disk of card, on each face of which a figure is painted, having a string attached to each end of the diameter crossing the figure, by which the card may be spun round that diameter as an axis. For since the successive impressions left by each of the full faces of the card, as they pass before the eye, become continuous with each other if renewed with sufficient frequency, the figure borne on one face is seen superposed on that borne on the other; and thus, if a bird be painted on one face and a cage on the other, or a vase on one face and a bouquet on the other, the revolution of the disk will cause the bird to be seen in the cage, and the bouquet in the vase. The distinctness of the image is of course impaired by the fact, that as the card is seen during the whole of its revolution, the two figures are presented to the eye in every successive phase of fore-shortening, as well as in full view; but as the latter makes the stronger and more persistent impression, it is that which forms the combined picture. The experiment may be easily varied by printing a word in large capitals on the two sides of the card, in such a manner that the upper half of each letter is on one side of it, and the lower half of it on the other; and if the relative places and positions of these two halves have been rightly adjusted, the revolution of the card will make them combine into one complete whole.

The *Colour-Top* of Mr. Gorham, again, presents a number of beautiful illustrations of the same principle, a description of which will be found elsewhere;* but we must stop to notice the elegant application of that principle to the production of images of *solid forms*, which has been recently devised by the same ingenious contriver. If a piece of metal, bent to the contour of one side of a vase, be made to revolve rapidly round an axis corresponding with that of the vase, a spectrum of the solid vase will be generated; and if there be fixed on the same axis a rod of glass bent to the contour of one side of a glass shade covering the vase, the spectrum

* See "Quarterly Journal of Microscopical Science," vol. vii. (1859), p. 69.

of such a shade, standing over the spectral vase, is produced by its revolution.*

This persistence of visual impressions has been also turned to account in the scientific investigation of sonorous vibrations. Thus, by throwing a beam of light upon a violin-string set in vibration by a bow, and observing the figure produced by the movement of the bright spot, Dr. Young was able to show that the middle point of the string, instead of merely moving from one side to the other in the same plane, describes various and sometimes very complicated curves, corresponding to different modes of drawing the bow; so that it is probable that the particular quality of tone evoked by different players from the same instrument has reference to the form of the vibrations produced by each. Following up the same line of inquiry, Professor Wheatstone examined the vibrations of elastic rods, fixed at one end, by watching the figures described by the point of light given by the reflection of a beam from a small bead attached to the free extremity of each; and the simple apparatus, termed the *Kaleidophone*, which he contrived for this purpose, is at the same time a beautiful philosophic toy, and an instrument of refined scientific inquiry.

Another of those simple and ingenious devices, in which this great inventor has been so fertile, is a *Photometer*, in which the motion of a reflecting bead gives a luminous figure, which may be a circle, a straight line, or any intermediate ellipse, according to the mode in which it is set on a disk which can be made to rotate round its own centre, whilst itself revolving round another centre. If light fall upon the bead from two lamps, whose relative illuminating power it is desired to determine, two similar figures are produced, in such close juxtaposition, that their relative degrees of brightness may be appreciated with great nicety; and thus, by moving one or the other of the lamps until the two figures exhibit the same degree of brightness, their relative illuminating powers are ascertained by the proportion between the squares of their respective distances from the instrument. When several beads are placed on it instead of one, a most beautiful effect is produced by the multiplication of the luminous figures, which consist of circles, ellipses, and straight lines, intersecting one another in various directions; each figure marking the course of one of the beads, which varies according to its position with reference to the centre of the rotating disk.

* This beautiful little toy, with a variety of devices, is sold by the London Stereoscopic Company, under the name of "The Optic Wonder."

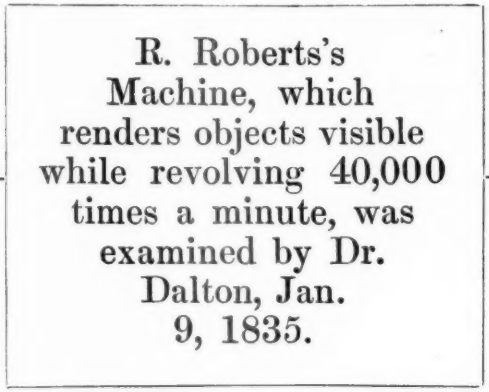
In all the cases hitherto cited, the persistence of the visual impression, after the withdrawal of its source, is marked by the production of a *line*, by the motion of a luminous *point*, or by that of a *surface*, by the motion of a luminous *line;* the duration of the original impression upon any one spot of the retina being almost infinitesimally small. The same principle, however, may be applied in quite an opposite manner. It was long since shown by Professor Wheatstone, that if a wheel in very rapid revolution be illuminated by an Electric discharge, the wheel is momentarily seen as if at rest; and, further, that it is even possible to record this stationary image photographically on a very sensitive surface; the duration of the illumination being so brief, that the wheel does not move in any appreciable degree whilst it lasts. By a calculation based on the actual rate of revolution of a wheel thus seen at rest, it has been shown by Professor Wheatstone that the duration of the luminous discharge does not exceed *one-millionth part* of a second. Now, it has become easy, by means of the Induction-coil, to obtain a succession of electric discharges following each other with such rapidity, that the visual impression left by one shall be continuous with that renewed by the next; and as each momentary impression is that of a *stationary* wheel, a *continuous image* of a wheel at rest is presented to the mind with such definiteness, that the fact of the wheel being really in very rapid rotation seems scarcely conceivable.*

The same result may be brought about by any mechanical arrangement that shall give a succession of glimpses of an object in motion, however rapid, which shall be sufficiently frequent to produce a continuous image; provided that the object be precisely in the same position on each occasion, so that each impression is identical with that which preceded and with that which follows it. Such an arrangement was carried out in an apparatus devised and constructed by the late Mr. Roberts, of Manchester—the celebrated machinist to whose ingenuity we owe the important invention of the "self-acting mule;" and was shown by him to the writer some twenty-five years since. A card (of which an exact copy is given over leaf), being rapidly whirled by a train of wheel-work round the axis A B,† the characters printed on it were blended, to ordinary

* This very beautiful experiment is at present being exhibited at the Polytechnic Institution.

† There is reason to think that the rate of revolution given to the card was considerably overstated; but the interest of the experiment would be precisely the same, whether the card revolved 4000 or 40,000 times in a minute.

view, into an indistinct haze; but when the card was viewed through a small hole to which the eye was applied, a stationary image of it

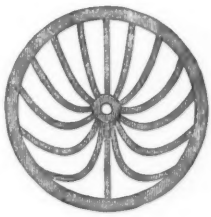


was seen, of sufficient distinctness to allow the printed characters to be read without difficulty. This was brought about by the interposition, between the eye and the card, of a rotating disk having a series of narrow slits at regular intervals, through which alone could the card be seen; the rate of its rotation being so proportioned by the train of wheel-work to that of the revolution of the card, that however rapid the latter might be, the card should always present its full face to the observer at the instant of the passage of one of the slits before the eye. Thus the eye received a succession of instantaneous glimpses of the card; and as its position was exactly the same at each recurrence, an impression was produced of sufficient continuity to give the effect of a stationary image, which was distinct enough to allow the print to be easily read.

Before we proceed to apply the principle which has now been so variously illustrated, to the explanation of the phenomena first brought into notice by Professor Faraday, it is but simple justice to an eminent man, who is now one of the oldest survivors of a past generation of our *savans*, to notice a memoir by Dr. Roget, that appeared as far back as 1825, wherein he calls attention to "a curious optical deception which takes place when a carriage wheel, rolling along the ground, is viewed through the intervals of a series of vertical bars, such as those of a palisade, or of a Venetian window-blind." Under these circumstances, a spectrum is seen of a wheel at rest, of which all the spokes, save those which are seen in the

vertical line, instead of appearing straight, seem to have a considerable degree of curvature; and this curvature progressively increases from the neighbourhood of the upper vertical spoke to that of the lower vertical spoke, as shown in Fig. 1,—the convexity of the curve being always turned downwards on both sides of the wheel, and the direction of their curvature being precisely the same, whether the wheel be moving to the right or to the left of the spectator. "The distinctness of this appearance," says Dr. Roget, "is influenced by several circumstances; but when everything concurs to favour it, the illusion is irresistible, and, from the difficulty of detecting its real cause, is exceedingly striking."

FIG. 1.



Like a true philosopher, Dr. Roget varied the conditions of the experiment, so as to determine what were *essential* and what *non-essential*; and was in this manner led to the determination of its very simple *rationale*. He found that it was essential that there should be a combination of a *progressive* with a *rotatory* motion; thus the spectrum will not be generated, if, while the bars are stationary, the wheel simply revolves on its axis, nor if the wheel simply moves onwards without turning round: but the appearance will be alike produced when the wheel rolls onwards behind the bars, or when the wheel revolves on a fixed axis and the bars are made to move onwards; or when, the bars and the axis of the revolving wheel being alike stationary, the spectator moves onwards, so that the images of the bars and of the spokes which fall upon his retina, change their relative situations, as if one of them moved onwards. It was found that the number of spokes in the *actual* wheel produced no difference in the degree of curvature they exhibit; but that the number of spokes in the *spectral* wheel depends partly upon the number in the actual wheel, partly upon the relative closeness of the vertical bars, and partly upon the rate of horizontal progress in the wheel. If the experiment be tried with a disk which, instead of being marked by several radiating lines, has only one radius drawn upon it, the spectrum shows a number of radii, each curved as in the figure; the number being that of the intervals between the bars which have been passed in one revolution of the wheel. If, on the other hand, a disk with several radii be employed, and the intervals between the vertical apertures are made to corres-

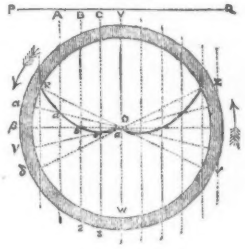
pond with the distances between the spokes at the circumference of the wheel, the images produced by the successive apertures will coalesce, so that the number of spokes in the spectral wheel is not augmented, but their distinctness is proportionally increased. But if the apertures between the vertical bars are made closer, the number of radii in the spectral wheel is increased, and their distinctness is proportionally diminished. The same result will happen if the wheel be made to move onwards more rapidly than it rolls; for the number of vertical apertures which it will pass in one revolution will then be augmented, just as if the apertures were themselves closer. If the bars, instead of being vertical, be inclined to the horizon, the same general appearances result; but the spokes of no apparent curvature are now those which occupy positions parallel to the bars. If, however, the bars be horizontal, and the onward movement either of the bars or the wheel be in the same direction, no spectrum whatever is produced; and, if the inclination of the bars be so considerable as to approach the horizontal, the distinctness of the spectrum is much diminished. But if, on the other hand, a progressive movement in the *vertical* direction be given either to the revolving wheel or to the horizontal bars, a distinct spectrum is produced, as in the first case—its straight spokes being now horizontal.

Lastly, it was noticed that the phenomenon was most distinct, (1) when the intervals between the bars are narrow; (2), when the bars are of a dark colour or shaded, a strong light being thrown upon the wheel; "the deception being further aided by every circumstance which tends to abstract the attention from the bars, and to fix it on the wheel."

The *essential* condition of the phenomenon having thus been found to be the combination of the rotatory movement of a wheel, with its onward motion in a direction contrary to that of the apertures through which it is seen, and the spectrum of a wheel with several radii being found to be producible by the combined rotation and onward movement of a disk with a single radius, the inquiry is so much narrowed, that the illusion can be readily proved to be referable to the principle already explained. This may be best shown by tracing out the succession of glimpses that we receive of a single radius O R (Fig. 2) in a disk revolving upon a fixed axis, through a single narrow vertical aperture that moves horizontally in the direction P Q, at a rate equal to that of the rotatory motion of the circumference of the disk. It is obvious that if, at the time of the transit of the aperture, the radius should happen to occupy either of the

vertical positions V O or O W, the whole of it would be seen at once through the aperture in its true position; but if, in the course of its revolution, it reaches the direction O R just at the time that the vertical aperture is opposite to R, the extremity R will be seen in that position, all the rest of the radius being hid. Whilst the radius is turning to *a*, the vertical aperture has moved on to A; and the point *a* of the radius is the only one that can then be seen through it, since at that point only is the radius O *a* intersected by the vertical line A 1. As the radius successively reaches the positions Oβ, Oγ, Oδ, the vertical aperture successively reaches the points B, C, V; and the points of the radius which will be successively seen through it are *b*, *c*, and *d*. If these two motions be mathematically combined, the continued intersection of the radius and the vertical is found to generate the curve R *a b c d*; and the like curve will be produced when the radius has passed the perpendicular O W, and is moving from O Y to O Z, whilst the vertical slit continues to advance at the like rate. Thus, then, by the temporary persistence of the impression left by each of the points of the revolving radius, as it is seen through the succession of apertures, the series of impressions is mentally combined into a curved line; and if the revolution of the disk be sufficiently rapid, the image of that curve remains impressed on the visual sense, until renewed by the recurrence of the same impressions. And it is obvious that, if either the apertures or the radii, or both apertures and radii, be multiplied, the same proportion being maintained, the effect will be only to multiply the number of glimpses received, while the intersecting points remain the same; so that the spectrum is increased in vividness, and can be completed by a less rapid rotation without any augmentation in the number of its radii. We see, moreover, why the spectrum is rendered more distinct by *the narrowing of the vertical apertures*; since, as in the preceding case, it is important that each glimpse of the spoke should be as nearly instantaneous as possible, so that the impression which it leaves in each part of its course may, like that given by Electric illumination, represent the object as at rest. —It is interesting to find that thus early in the investigation, Dr. Roget had distinctly noticed the practical importance of this point,

FIG. 2.



which we shall find to be essential to all the higher developments of the same fundamental principle.

It was about five years after the publication of Dr. Roget's memoir, that Professor Faraday, being at the lead-mills of Messrs. Maltby, had his attention drawn to two cog-wheels which were moving with such velocity, that if the eye were retained immovable, no distinct appearance of cogs in either could be observed; but when he stood in such a position that one wheel appeared behind the other, he immediately perceived the distinct though shadowy resemblance of *cogs moving slowly in one direction*. "Mr. Brunel described to me," he continues, "two small similar wheels at the Thames Tunnel: an endless rope, which passed over and was carried by one of them, immediately returned and passed in the opposite direction over the other, and consequently moved the two wheels in opposite directions with great but equal velocities. When looked at from a particular position, they presented the appearance of *a wheel with immovable radii*."

The observation was not really as novel as Faraday supposed it to be; for the production of a stationary spectrum by two cog-wheels revolving with equal velocities in contrary directions had been distinctly recorded in 1828 by M. Plateau, who correctly interpreted it on the basis previously laid down by Dr. Roget, to whose memoir he referred. His short notice of the phenomenon (published in Quetelet's "Correspondance Mathématique et Physique," tom. iv., p. 393) seems not to have excited general attention; and there can be no doubt that it was unknown to Professor Faraday, whose interest in the phenomenon witnessed by himself, led him both to devise methods for reproducing it experimentally in various forms, so as, by varying its conditions, to ascertain the influence of each upon the result; and also to investigate the problem theoretically with his usual felicity.

The experimental apparatus which Faraday devised was remarkable alike for its extreme simplicity, and for its varied capabilities. Its foundation consisted of a horizontal board, on which was fixed a vertical board cut out so as to form a central and two lateral supports, as shown in the Plate, Fig. 2. Each of these supports was capped by a little piece of thin copper-plate, bent into such a shape as to form a bearing whereon might rest the extremity of an axis; the middle support having a double bearing, one on either side, and the lateral supports a single bearing. The axes were two small pieces of steel wire, tempered at the extremities; each having upon it a little roller of soft wood, which, though it could be slipped by

force from one part of the axis to the other, still had sufficient friction to carry the axis with it when turned round. To these axes, resting, one on either side of the central support, quite independently on their respective bearings, motion was given by a circular disk of copper; the lower surface of which was covered with a piece of fine sand-paper attached by cement; whilst to the upper was attached a pulley working on an upright spindle fixed into the central support, and capable of being turned either by the hand or by a band connected with a revolving wheel. As this disk, when in place, rested on the rollers of the two axes, its rotation would cause the axes to revolve in opposite directions; and their velocities, which were equal when the rollers were set at equal distances from the centre of the rotating disk, could be made to differ in almost any ratio, by shifting one of the rollers nearer to or farther from that centre. The wheels which were made the subjects of experiment were cut out of cardboard, and were about seven inches in diameter. To the middle of each was attached by cement a little disk, cut off the end of a phial-cork; and a central hole having been made with a needle through both card and cork, the wheels could be slipped on the axis sufficiently tightly to turn with it, and yet loosely enough to be easily removed, so as to admit of the ready exchange of one for another.

When two equal *cog*-wheels, of the form shown in the Plate, Fig. 1, placed on the two axes, were made to move in contrary directions, with equal velocities, and the eye was placed at such a distance in the line of the axes that one wheel was seen superposed on the other, with a dark background behind them, in place of the uniform tint exhibited by a single wheel in rapid revolution, a stationary spectrum of a cog-wheel was distinctly seen. This spectrum, however, was peculiar in two particulars; first, that the number of cogs was double that of the actual wheels; and, second, that the white cogs and the dark intervals between them graduated into each other, instead of being separated by defined lines. When one wheel was made to revolve a little faster than the other, by shifting its wooden roller further from the central support, the spectrum travelled in the direction of the wheel having the greater velocity; its rate of revolution being the *excess* of that velocity above the opposite velocity of the other wheel. And if, instead of employing two wheels with the same number of cogs, one of the wheels had a cog or two more than the other, and both were made to revolve with the same velocity, the spectrum travelled in the direction of the wheel having the greater number of teeth. But if,

again, the wheel having the smaller number of cogs were made to revolve with so much greater a velocity than the other, as would equalize the number of cogs of the two wheels that would pass any given point in a certain time, the spectrum became stationary again.

If the wheels were looked at from a point not in the prolonged axis of both, so that one was only in part superposed visually on the other, the effect took place only at that part; and "it was striking and extraordinary," says Faraday, "to observe, as it were, two uniform tints mingling, and instantly breaking out into the alternations of light and shade which I have described."

When *spoke*-wheels were put on the machine instead of cog-wheels, the effect was essentially the same; each wheel giving a perfectly uniform tint when made to revolve by itself, or when looked at obliquely; but a stationary spectrum, having double the number of spokes, being distinctly seen when the eye was so placed that one wheel was visually superposed on the other. Any difference, either in the number of spokes, or in the velocities of the two wheels, caused the spectrum to revolve, as in the cases already described.

The *rationale* of all these phenomena is by no means difficult of comprehension, when the movements of the wheels are studied with reference to the principle already stated, as to the sensible duration of visual impressions; and when we connect with this the principle now rendered familiar by the effects of the Stereoscope; namely, that of the *mental* combination of two or more sets of sensory impressions, which are received either at the same time or in such quick succession as to be continuous.

For the sake of simplicity, it is convenient to examine a case in which the edge only of one cog-wheel is visually superimposed upon that of another travelling in the opposite direction, as shown in the Plate, Fig. 6, in which the continuous line gives the outline of the cogs of the upper wheel travelling from left to right, whilst the dotted line gives the outline of the cogs of the lower wheel travelling with the same velocity from right to left. Now, supposing that the eye be directed towards a point, l, of a bright background beyond the cogs, it will be found that this point will be eclipsed by the cogs a and b simultaneously, for they begin to cover it and they leave it together; whilst, on the other hand, the point l' is left uncovered at the same time by the interval between the cogs a and c of one wheel, and by that between the cogs b and e of the other. The points l and l' of the background, therefore, are alternately open-to and shut-from the eye for equal times, since what these

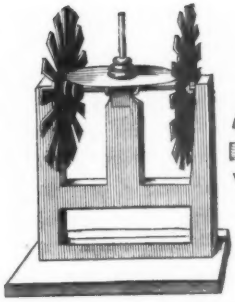
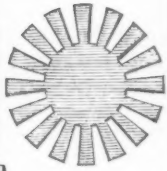


FIG. 2.

FIG. 1.



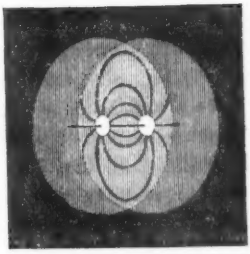


FIG 2.

FIG. 4

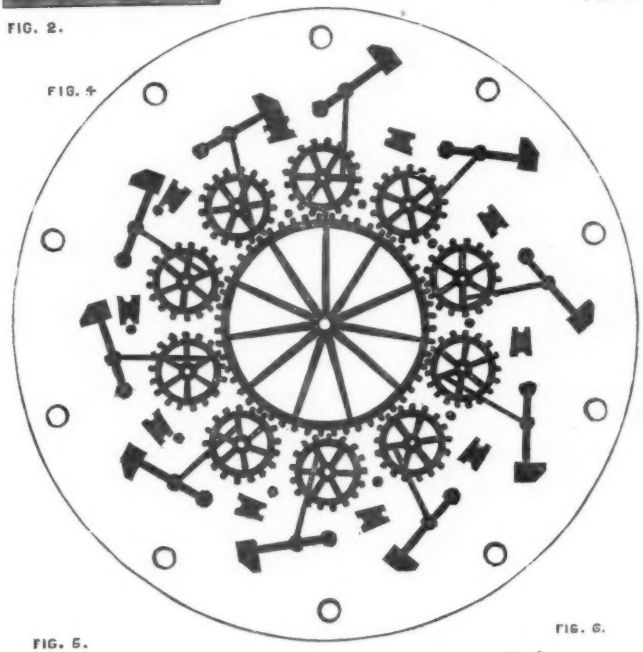


FIG. 5.

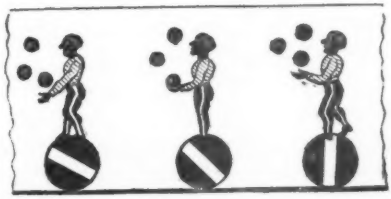


FIG. 6.

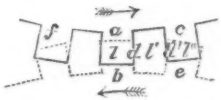
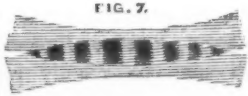


FIG. 7.



cogs do will be done by all the other cogs in turn; half the light, therefore, from those points of the background comes to the eye, and produces a corresponding impression.

But with respect to the intermediate points, *d*, *d′*, the case is different; for, although the cog *b* of the lower wheel is just about to leave *d* exposed, by moving towards the left, the cog *a* of the upper wheel is just about to eclipse it by moving towards the right; and by the time this has passed over it, the cog *e* of the lower wheel has come to *d* from the right, and eclipses it until cog *f* of the upper reaches it from the left. In like manner, while the point *d′* is just being left by the movement of cog *c* of the upper wheel towards the right, it begins to be covered by the movement of cog *e* of the lower wheel towards the left; and by the time this has passed it, the movement of the upper wheel towards the right has brought the foremost edge of cog *a* to impinge upon *d′*, which remains covered by that cog until another cog of the lower wheel comes into the position of *e*. Thus, therefore, the points, *d*, *d′*, of the bright background suffer constant eclipse; and if the wheels be themselves black, those points will show a maximum of darkness. Following out the same method of inquiry, it will be found that the points intermediate between the maxima of light, *l*, *l′*, *l″*, and the maxima of darkness, *d*, *d′*, are eclipsed for intermediate periods, varying as they are nearer to the former or to the latter; and thus a graduated shading-off will be produced between these successive points, giving rise to such a stationary spectrum, formed by an alternation of light and dark spaces, as is represented in Fig. 7. The central light space of this, it will be seen, corresponds to *l*, Fig. 6, the dark space on the right of it to *d*, the next light space to *l′*, the next dark space to *d′*, and so on; the number of alternations of light and dark spaces being double that of the cogs of the wheels.

Adverting to the previous observations of Dr. Roget, Professor Faraday showed how they might be experimentally verified by making one of his wheels rotate behind a strip of card with vertical slits, either the card or the wheel being moved horizontally at the same time; and he also drew attention to a variation in this phenomenon, which is observable when two wheels, revolving in the same direction (as those of a gig), are seen so obliquely that one is only in part projected on the other. A stationary spectrum is then seen, corresponding with that represented in the Plate, Fig. 3; which may be readily reproduced experimentally by cutting a pair of spoke-wheels out of card-board, passing a piece of wire through the centres of both so that they shall be three or four

inches apart, and then making them rotate, by turning the wire between the fingers, in such an oblique position relative to that of the eye, as shall superpose one side of the near wheel on the opposite side of the more remote.

The most important part of Professor Faraday's paper, however, in regard to the subsequent development of his fundamental "idea," is his almost incidental statement, that if *a wheel be made to revolve before a looking-glass, and the image be looked at through the spaces between the cogs or spokes of the actual wheel, a stationary spectrum will be perceived; and this spectrum, instead of having the number of its cogs or spokes doubled, will have the same number as those of the actual wheel.* He did not attempt to explain this phenomenon; the *rationale* of which is by no means obvious, seeing that the actual wheel and its reflected image move in the same, not in opposite directions.

The following is the account given of it by Professor Plateau (Op. Cit., tom. vii., p. 366):—"Every time that a slit passes the eye, it permits the observer to see the image of the disk in the mirror; but in virtue of the narrowness of the slits, this image can only be seen during so small a part of a revolution that it is in effect almost stationary. Now it is evident that the images which thus succeed one another on the retina are perfectly identical, and that, in virtue of the duration of the impressions which they leave, they will produce, if the rate of revolution be sufficiently rapid, a continuous image of the disk, with its radii and its slits apparently motionless." It thus appears that the production of the spectrum depends in this case, not upon the conditions previously investigated by Faraday in the case of the two wheels revolving in opposite directions, but upon the limitation given to the recurring glimpses of the moving object, as in the apparatus of Mr. Roberts; the fundamental principle, however, being the same in both instances.

That Professor Plateau's explanation is the true one—this phenomenon having nothing in common with the production of a stationary spectrum by two wheels revolving near each other in opposite directions, except in so far as both depend upon the persistence of visual impressions—will appear from the following simple experiment which the writer has devised for the sake of putting it to the test. If we look from a distance of two or three feet at a wheel resembling that represented in Fig. 1 (Plate), through another similar wheel held *near the eye*, and both be made to revolve in the *same* direction with equal velocities, a stationary spectrum will be seen having *the same* number of rays as the actual wheel; and the

like result presents itself when the directions of the two revolutions are *opposite*. The effect is improved by narrowing the slits of the nearest wheel; and they may be reduced in number, by closing any of them, without altering the result. In fact, even a single slit will answer the purpose, provided the rate of revolution be rapid enough to allow the successive impressions received through it to produce the effect of a continuous image. Hence it is obvious that the effect is here produced, as in the view of the image of the wheel made to revolve before a mirror, by the mental combination of the series of momentary glimpses which we gain of the entire *back* wheel, as the openings in the *front* wheel pass successively before the eye; and that the stationariness of the spectrum will depend upon the exactness of the correspondence between the relative positions of the rays and of their interspaces in each successive glimpse. As this correspondence must always be precise when the image of the revolving wheel is looked at in a mirror, the resulting spectrum will be *perfectly* stationary; but this *entire* absence of motion in the spectrum can scarcely be attained when the experiment is made with independently-revolving wheels, without a greater perfection in the apparatus for giving motion to them than ordinary workmanship will ensure.—Some further experiments, suggested to the writer by the singular results of the change above described in the relative distances of the eye and the wheels, will be described in a future paper.

It is not a little interesting to find Professor Faraday applying his discovery to the explanation of a phenomenon which was at that time a complete puzzle to Microscopists,—the apparent rotation of the "wheels" of the *Rotifer*, which, even under the imperfect instruments then in use, was so distinct as almost to force the observer to admit their existence as parts of the animal body, although it was not conceivable *how* they could have such a motion, unless detached from it. "It is certain," says Baker, "all appearances are so much on this side the question, that I never met with any who did not, on seeing it, call it a *rotation*; though, from a difficulty concerning how it can be effected, some have imagined they might be deceived. M. Leeuwenhoek also declared them to be *wheels that turn round*." "Notwithstanding," says Faraday, "the evidence adduced by Mr. Baker, which is admitted by some at the present day, it must be evident, from a consideration of the nature of muscular force, and the condition of continuity under which all animals exist, that the rotation cannot really occur. The appearances are altogether so like some of those exhibited in the experiments already described, that I feel no doubt the wheels

must be considered not as having any real existence, but merely as spectra, produced by parts too minute, or else having too great a velocity when in use by the animal, to be themselves recognized. Thus, if that part of the head of the animal were surrounded by fibrillæ, endowed each with muscular power, and projecting on all sides, so as to form a kind of wheel; and if these fibrils were successively moved in a tangential direction rapidly the one way, and more slowly back again, it is evident that currents would be formed in the fluid, of the kind apparently required to bring food to the mouth of the animal; and it is also evident that if the fibrils, either alone or grouped many together, had any power of affecting the sight, so as to be visible, they would be less visible at the part through which they were rapidly moving, than at that through which they were slowly returning; and at that place, therefore, an interval would appear, which would seem to travel round the wheel, in consequence of the successive action of the fibrils."—How true was this sagacious surmise of our great philosopher, is known to every one who now examines the beautiful action of the "wheels" of the Rotifer, with the advantage of superior instruments, and the knowledge derived from the study of Ciliary action elsewhere.

It occurred to the writer, when repeating Professor Faraday's experiments at the time of their first publication, to try the effect of substituting for the hinder wheel, when two were employed, a disk painted in alternate sectors of two colours, corresponding in number with the cogs of the front wheel; and he found, as he expected, that whilst the revolution of this disk blends its colours into a uniform mixed or neutral tint, the interposition of the cog-wheel revolving at the same speed in a contrary direction, gives a spectrum of the disk at rest, with twice the number of coloured sectors, the colours graduating into one another like the lights and shades of the spectral wheel (Fig. 7). Even three or four colours were thus separated, by disposing them in triple or quadruple alternation; the number of sectors of each colour being made equal to that of the cogs of the interposed wheel.

Again, Professor Faraday having mentioned that when the cogs or slits in the wheels are disposed obliquely instead of vertically, and the obliquities have opposite directions, the stationary spectrum has its slits vertical, the writer varied the experiment by giving a considerable circular curvature to the slits; and found that when these curvatures were equal and in opposite directions, the two wheels revolving with the same velocity, the edges of the slits in the stationary spectrum were quite straight. This is not the case,

however, when the experiment is made with a single wheel before a mirror; for the spectrum then represents the actual wheel, whether its slits be vertical, oblique, or curved.

A variation which was very early devised in the experiment with the single wheel before the mirror, is worth mentioning here, as furnishing the key to that forward or backward movement of the figures in the Zoetrope, which is intelligible enough when thus explained, although very puzzling to such as have not grasped the very simple principle to which it is to be referred. If three concentric circles of slits be cut out of a disk, and their numbers be slightly dissimilar—say *eleven* in the innermost, *twelve* in the intervening, and *thirteen* in the outermost—it will be found that as we look at the image in the mirror through one or another of these circles, the appearance of the spectrum will vary. Thus, if we look through the *outermost* circle, that one will be stationary in the spectral wheel; the intervening circle will revolve slowly in a direction contrary to that in which the wheel is actually rotating; and the innermost circle will revolve in the same direction with the preceding, but with twice its rapidity. If we look through the *intervening* circle, that one will appear stationary, while the outer circle will revolve slowly in the direction of the actual revolution, and the inner circle will also revolve slowly, but in the opposite direction. Finally, if we look through the *innermost* circle, that one will appear stationary, the intervening circle will revolve slowly in the direction of the actual revolution, and the outer circle will revolve in the same direction with the preceding, but with twice its rapidity. These results are merely variations of Faraday's original experiment (p. 437), in which one of the two cog-wheels revolving in opposite directions was made to move somewhat faster than the other, or was set with a greater number of cogs;—in either instance the number of cogs of the one wheel which pass before the eye in a given time being greater than the number of those of the other wheel passing in the same time, and the motion of the spectral wheel representing that difference. When we look at the image of the revolving wheel in the mirror, the spectra of the circles that have a *greater* number of slits than that through which we are looking, revolve *forwards* (or in the direction of the actual revolution), while those having a *less* number move *backwards* (or in the reverse direction); their rates of revolution being proportional to the numerical ratio between *their* slits and those of the circle through which we see them.

(*To be continued.*)

WOMANKIND:

IN ALL AGES OF WESTERN EUROPE.

BY THOMAS WRIGHT, F.S.A.

CHAPTER IV.—(*Continued.*)

THE ANGLO-SAXON WOMEN.

It is curious that Aldhelm and the other writers of that class, say nothing of this practice of dyeing the hair, though they accuse the ladies of curling it and of painting their cheeks. Perhaps, however, these Anglo-Saxon Latin writers were applying to their countrymen and countrywomen the denunciations of the southern ecclesiastics of Gaul and Italy. They seem to have overlooked a little what was going on at home, and they may have thought only worthy of condemnation that which they found condemned by authorities nearer Rome; or, perhaps, they had a taste for blue hair. At all events, the existence of blue hair is not alluded to by the Anglo-Saxon writers, whether in their own vernacular tongue or in Latin. But, among the Anglo-Saxon, as among the Franks, the hair was an object of great importance. In earlier times, the cutting of the hair in either sex indicated slavery, or crime which merited the severest punishment. Even down to the present day, the condemned criminal has the head shaved. Among the Anglo-Saxons, long and loose hair in the female sex was typical of freedom and of pure virginity. Hence, in earlier Anglo-Saxon times, an unmarried girl was obliged to wear her hair in this condition. The only indulgence was, that, after a certain age, she was allowed to plait it. On her wedding-day she unplaited it, and threw it loose and scattered over her shoulders, because this indicated her nobleness of birth as well as her virginity. After the marriage, however, the woman's hair was cut short, to show that she had accepted a position of servitude towards her husband; but, as civilization developed itself, this degrading part of the marriage ceremony was dispensed with, and brides were only required after the ceremony to bind their hair in folds round the head. Loose hair continued to be the distinction of an unmarried girl, while a married woman was known by her hair being bound up. Even this distinction seems to have been kept up in practice till a very recent period.

There is a part of the costume to which I have not yet alluded, the shoe. There appears to have been among the Anglo-Saxons no

difference between the shoe (*sceo*) of the two sexes; both are usually represented black, though at times various colours are introduced; and both are represented as rising to the ankle, as having an opening down the instep, and as fastened at the top by a thong (*sceo-þwang*). This form of shoe was, in all probability, derived from the Romans, as it is exactly that of the Roman shoes procured by Mr. Roach Smith from excavations in London.* Among princes and nobles, and especially among the higher ecclesiastics, the upper leather appears, among the Franks and among the Anglo-Saxons, to have been often stamped or punched with elegant patterns similar to those of the shoes described by Mr. Smith. Perhaps, also, the soles of the shoes were studded with nails like those of the Romans, for we find in the Anglo-Saxon glosses the word *sceo-nægel*, a shoe-nail.

The men among the Anglo-Saxons certainly wore stockings, and there can be little doubt that they were worn by the women also; we know nothing of the material of which they were made; but that of the men appears from the illuminations of the time to have been of different colours. The Anglo-Saxons also wore gloves, for the word (*glóf* in Anglo-Saxon, and *glófi* in Old Norse) belongs to the Anglo-Saxon and Northern languages. We trace them on the hands of ladies in one or two instances in the drawings of Anglo-Saxon manuscripts, but the word itself cannot have been of very common use, for we find, especially in the older writers, that, instead of using the correct names, they speak of the glove by the rather singular name of a hand-shoe (*hand-sceo*).† It has been remarked by some of our writers on costume, that the Anglo-Saxons never went without shoes; that even labourers, though generally represented as bare-legged, are not represented bare-footed. This, however, is not strictly correct; at least as applied to the female sex. The party of gossips in the accompanying cut, taken from the Harleian Manuscript, No. 603, already described (fol. 12, r°), are

ANGLO-SAXON GOSSIPS.

* Descriptions with engravings of these Roman shoes, which are now in the British Museum, will be found in Roach Smith's "Illustrations of Roman London."

† The first gloves among the Germans and Scandinavians appear to have been warlike implements, things fitted upon the hands with which you could scratch and tear in a very destructive manner.

bare-footed as well as bare-legged, and the infants they carry in their arms are entirely naked. No doubt they belong to the lower classes of society. In our last cut (page 356), we have seen a woman leading by the hand a child of a more advanced age, who is similarly naked. These examples would seem to show that, among the lower orders of Anglo-Saxon society, the children were allowed to go naked until the age when they could be left to walk about by themselves.

As stated before, the wife, though above all the rest of the family, was inferior to and dependent upon her husband. He was the sole possessor, and everything in the house originated from him. If he made war, the spoils taken from the enemy, as far as his followers were concerned, belonged to him, and he distributed them among his warriors. The duty of distributing his gifts appears to have been considered to belong to his wife, and was performed at the great feasts. Then the chieftain's wife, the lady of the household, from time to time, rose from her seat and crossed the hall, and not only served the ale or mead to the guests, but delivered to them the presents destined for them by her husband; and in this she was assisted by her daughters, or by some other noble females attached to her person. In the poem of Beowulf, Hrothgar's queen is represented as performing this office :—

Hwílum mæru cwén,	At times the great queen,
friðu-sibb folca,	the peace-tie of peoples,
flet eall geond-hwearf,	all traversed the hall,
bædde byras geonge;	her young sons addressed;
oft hió beáh-wriðan	often she a ringed wreath
secge sealde,	gave to the warrior,
ær híe to setle gong.	before she returned to her seat.
Hwílum for duguðe	At times before the nobles
dóhtor Hróðgáres	Hrothgar's daughter
eorlum on ende	to the earls in order
calu-wæge bær,	bore the ale-cup,
þa ic Freáware	whom I Freáware
flet-sittende	the court residents
nemnan hyrde,	heard name,
þær hió gled-sinc	where she bright treasure
hæleþum sealde.	gave to the warriors.

"Beowulf," l. 4038.

On reading this, we more fully understand the force of the passage of the Gnomic Poem in the Exeter Book, which tells how an earl's

wife—earl was the title assumed by the head of the family—was usually beloved of her people:—

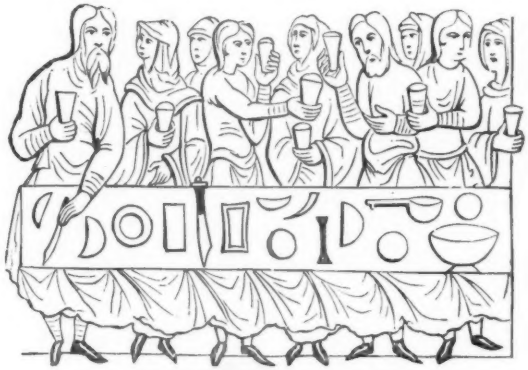
And wif geþeon,	and his wife (shall) flourish,
lof mid hyre leodum,	beloved with her people,
leoht-mod wesan.	be of cheerful mind.

Thorpe's "Codex Exoniensis," p. 338.

If the head of the family had store of bread, it showed that he possessed broad lands, and that he cultivated them. There were three words in the Anglo-Saxon language, which indicated, almost poetically, the position of the different parts of the family towards each other. The chieftain himself was called the *hlaf-ord*, the origin or source of the bread, he to whom it belonged; his wife was the *hlaf-dig*, the distributor of the bread; his retainers and his servants, and all who lived at his table, were called *hlaf-ætas*, eaters of the bread. The two former words, *hlaford* and *hlafdig* gradually took a nobler place in our language, and are now represented by the well-known words *lord* and *lady*.

It has been supposed that it was only towards the tenth century that the women of the household gained the right of sitting at table with the men, and that this is evidence of a great advance in their social position. This, however, may be an assumption founded too hastily upon our mere want of knowledge. We must bear in mind that the dinners described by the poets and other early writers are usually great feasts, more or less of a ceremonial character. The guests seem not generally to have taken their ladies with them, and the ladies of the household who were worthy to accompany their chief and his lady were few in number; and it is not stated by the writers who describe these scenes that they were not in the hall. I have shown, in a previous chapter (STUDENT, No. III., p. 172), that, according to the ideas of the Scandinavian mythology, the gods and goddesses sate together in hall, without any distinction. We find several pictures of table scenes in the later Anglo-Saxon manuscripts, of which we give one in the accompanying cut. It is taken from the manuscript of Alfric's translation of Genesis (MS. Cotton., Claudius, B. IV., fol. 36, v°), where it is intended to represent the feast given by Abraham on the occasion of the birth of his child. The guests are seated at a long table, and are in the act of drinking from the ale-cups, and pledging each other. It will be seen that men and women are here mixed together without any order, the latter distinguished by having their heads always covered with the head-rail.

It may be doubted, indeed, whether this picture of the two sexes sitting together indiscriminately at table be a proof of



ANGLO-SAXON LADIES AT TABLE.

an improvement in woman's position in society; but there can be no doubt, that for this improvement she was indebted in a great measure to the interference of the Christian clergy. They laboured to destroy, or at least to diminish, the old patriarchal spirit, and to emancipate the female sex from the too great authority of fathers and husbands. Some old customs were abolished at an early period after the introduction of Christianity. Among these was polygamy, which certainly existed among some branches of the German race, and which we have seen was practised among the gods of Scandinavian fable. There can hardly be a doubt of its existence among the Anglo-Saxons, at least in their earlier times, because at a later period we find it forbidden by law. One of the code of laws of the Northumbrian priests prohibits, "with God's prohibitions, that any man have more wives than one."* This prohibition, it will be remarked, belongs to the ecclesiastical law; it is not found in the secular laws. It appears to have been the usual custom throughout the Germanic race, when a head of a family died, leaving a wife by a second marriage, that the son and heir married his step-mother. Perhaps she was considered as a part of the father's property, and therefore of the son's heritage. This practice was proscribed by the Church. Ethelbert, King of Kent, the first Anglo-Saxon king who embraced Christianity, took a second wife after the death of his first queen, the Frankish princess, Bertha. His son, Eadbald, was in his heart

* "Ancient Laws and Institutes of England," vol. ii., p. 301.

opposed to the new faith. When Ethelbert died, in 616, and Eadbald succeeded to the throne, the latter at once rejected Christianity, and, returning to the customs of his ancestors, married his father's widow. The well-known miracle by which King Eadbald was converted and reformed is related by Bede, who tells that he "abjured the worship of idols, and renounced his unlawful marriage"—unlawful, of course, only under the ecclesiastical laws. At a later date, Ethelwulf, King of Wessex, the father of Alfred, in his old age took for his second wife Judith, the daughter of Charles the Bald, of France. On his death, in the year following (857), his son Ethelbald, who succeeded him, married his widow, Judith. The clergy were indignant, and Swithun, Bishop of Winchester, persuaded him to separate himself from her.

(*To be continued.*)

STEIN ON THE INFUSORIA.—BOUNDARIES OF THE GROUP.

The second part of Dr. Friederich Stein's great work on the organization of Infusoria, "Der Organismus der Infusionsthiere," contains a great mass of important matter. We propose, from time to time, to lay some of his principal facts, observations, and theories, before our readers.

Referring to the classification of Infusoria, he recites Lachmann's observations on the outward openings of the contractile vesicles of an Acineta which he discovered on a water-beetle, and observes that Lachmann rightly concluded that these organs are not to be regarded as heart-like centres of a circulatory system, but as excretory organs. Lachmann differed afterwards from the opinion of his friend Claparède, and wished to replace the Rhizopod-Infusoria in the class of Infusoria. The only definite reason for this course (with which Joh. Müller coincides) is, that the Rhizopod-Infusoria possess, like all real Infusoria, contractile vessels; but the undoubted Rhizopods do not possess them. It is not clear why this reason—the correctness of which is not at all yet decided—should be made thus decisive, as it is opposed by an equally important one, which, in an equal degree, demands and justifies the connection of the Rhizopod-Infusoria with the other Rhizopods, namely, that all real Infusoria move by means of cilia; but that, on the contrary, the Rhizopod-Infusoria move, like all other Rhizopods, by means of pseudopodia. All the rest of their organization, and especially their

manner of taking food, and the rejection of the indigestible remains, speaks clear enough for the connection of the Rhizopod-Infusoria with the true Rhizopods. The Infusoria which take solid food, and which are certainly the greater number, possess always on invariable parts of the body a mouth and an anus; the Rhizopods and Rhizopod-Infusoria, on the contrary, are able to take in and excrete solid matter at all parts of the surface of their bodies, or, at any rate, throughout a larger or smaller portion of their surface; but in no case has a real mouth or anus been discovered.

Even the Acinetans, who do not possess a real mouth or anus, stand, as regards taking food, in a totally different relation to the Rhizopod-Infusoria, and these latter could, were they to be arranged with the Infusoria, only be placed between the Acinetans, and the Flagellate-Infusoria, because the Acinetans take only fluid food with the widened points of their suckers. And then would it be possible to separate animals who are in most regards so similar to each other as the genus Euglypha, Duj.; Cyphoderia, Schlumb. (Lagynis, Schultze), Trinema, Duj.; and Coryzia, Duj., on one side, and the genus Gromia on the other, without a violation of nature? Therefore it is not to be doubted that Rhizopod-Infusoria are to be ranked with the class of the Rhizopods.

E. Haeckel also defends this position in his masterly Monograph of the Radiolaria. On the other hand it seems to him indeed as if the Rhizopod-Infusoria formed a thoroughly distinct division of organisms, sharply opposed to the general mass of all the other Rhizopods, there being no possibility as yet of placing them in a systematical position, as their animal nature is even not yet sufficiently settled. It would be conceivable to doubt the animal nature of the Amœbæ,* considering the facts known with regard to the Myxomicetes; but it appears very strange that Haeckel raises also doubts concerning the animal nature of the Arcellinæ, in which he differs from all hitherto received opinions. Proceeding from a theoretical point of view, Haeckel has arrived at very singular notions concerning the limits between the animal and vegetable kingdoms which should have aroused his misgivings with regard to the principles from which he took his departure, as they are in contradiction to the results of all the modern researches on Infusoria. In fact, Haeckel comprises in the class of the Infusoria only my orders of the Peritrichal,† Hypotrichal, Heterotrichal, and Holotrichal

* Dr. Wallich's researches are quite sufficient to decide the animal nature of the Amœbæ.—Ed.

† For explanation of these divisions see Student for May.—Ed.

Infusoria, which he recognizes as natural, and the Acinetans; but all the Flaggellate Infusoria he banishes to the vegetable kingdom. Of the reasons for assuming the animal nature of the Flagellate Infusoria given in the first part of my work, Haeckel has taken no notice at all. It only remained doubtful whether the Volvocinæ* appertained to the animal kingdom; but all the other Flagellate Infusoria are recognized by the general assent of investigators as decided animals.

Claparède and Lachmann differ also considerably from the hitherto prevailing view concerning the position in which the Infusoria are to be placed in the animal kingdom, I am opposed to their opinion. They do not deny that the Infusoria belong to the simplest animal organisms; but, notwithstanding this, they will not class them in a distinct group of the Protozoa at the end of the animal kingdom; they maintain the opinion that they are most closely connected with the preceding animal groups, and should be subordinated to them. They affirm, especially, such an unquestionable analogy between the Infusoria on one hand, and the Polyps and Acalephs, or Leuckart's Cœlenterates on the other, that they think themselves forced to consider the Infusoria only as a simple subdivision of the Cœlenterates.

This paradoxical view finds support principally in Claparède and Lachmann's equally erroneous opinion of the composition of the body of Infusoria, as given by Lachmann on page 58 of the first part of his essay, affirming that the body of the Infusoria consists, on its outmost layer, and to a very slight depth only, of real contractile parenchyma, and that the whole interior is filled with chyme, and the food taken into the digestive cavity which communicates with the exterior, either through the mouth, or through a tube leading from it.

There certainly would be a remarkable analogy between the Cœlenterates and the Infusoria if this opinion were correct, as it is one of the chief features of the Cœlenterates, that their mouth leads directly into a very large general cavity of the body, or into a larger or shorter tube, ending in that cavity.

But to this analogy it is impossible to attach much value; and also it is inapplicable to a considerable number of the Infusoria: namely, the mouthless Opalinæ and Acinetans. Moreover, the tube following the mouth represents, in such Cœlenterates as possess it, the real digestive organ, while with the Infusoria it represents only the œsophagal canal.

* This is no longer doubtful.—Ed.

This presumed analogy loses still more value when we consider how totally different is the remaining organization of the Cœlenterates from that of the Infusoria. The Cœlenterates exhibit a radiate arrangement of their parts, while the greater number of the Infusoria are bilateral animals. The Cœlenterates do not possess an anus; the Infusoria commonly have one. Further, the body cavity of all the Cœlenterates provided with an intestinal tube (the Polyps) is divided by radial partitions into compartments; the Infusoria, on the contrary, have nothing analogous to this, and even the true limits of their supposed body cavity can not be determined with certainty; while the body cavity of all the Cœlenterates is lined by a proper epithelium, and consequently always forms a sharply-defined space. The most essential and characteristic organs of the Infusoria are the nucleus and the system of the contractile vessels, and the Cœlenterates have nothing analogous to these. Finally, there is a most important morphological character, which forms a fundamental division between the Infusoria and the Cœlenterates, and makes all alliance between those two classes of animals impossible; viz., the body of the Cœlenterates is formed of cells, originating out of the division of the impregnated yolk. It may therefore be regarded as an aggregation of cells. But the body of the Infusoria is developed from a single cell, which only enlarges and alters into various shapes. Consequently there are always cells or nuclei visible in the body tissue of Cœlenterates, which originated from the metamorphosis of cells. But this is not the case with the Infusoria; their body tissue consists of a certainly not indistinct, but still always homogeneous and structureless substance, "the sarcode," of which we shall speak by and by.*

Agreeing with Claparède and Lachmann, I formerly took for granted that the Infusoria were provided with a digestive cavity; but, notwithstanding this, I never could find any relation between Cœlenterates and Infusoria which would justify ascribing to the latter the organization-plan of the Cœlenterates. Now, I still adhere to my first opinion, that the body of the Infusoria consists throughout entirely of sarcode, and that the body cavity filled with chyme is nothing else than an inner tissue formed of softer and yielding sarcode. The inner tissue passes very gradually outwards into the investing tissue, consisting of a tougher and more resisting sarcode, and covered on its outer surface by the cuticle which Claparède and Lachmann regard as the only body tissue. I consequently believe in no relation at all, or near connection, between

* Are these distinctions as clear and precise as Stein asserts?—Ed.

the Cœlenterates and the Infusoria, and in my opinion no course is possible but to regard the Protozoa as a special group.

Within this group the Infusoria have to all appearance their place, and it cannot be denied that they comprise the simplest animal organisms. The Infusoria are joined immediately by the Rhizopods, with which I associate the Gregarines, and which form a separate order. Such an unmistakably close relation exists between the Amœbæ (whose connection with the Rhizopods I take for granted) and the simplest forms of Gregarines (as contained in my genus Monocystis), that it seems to me impossible to place animals that are so similar in their organization and vital actions in different classes of the animal kingdom.

GLOBULAR CLUSTERS OF STARS.

BY REV. T. W. WEBB, M.A., F.R.A.S.

Few objects in the sidereal heavens are more interesting than the compressed masses of minute stars with which they are studded at irregular intervals, and which are known among astronomers by the name of "globular clusters." By far the greater part of these are only perceptible with telescopic aid, the keen-sighted Argelander having reckoned as visible without it, that is in northern Europe, only three properly so-called, two in the constellation Hercules, and one in Pegasus; though he enumerates fifteen "cumuli" or heaps of stars, which at a greater distance from us would assume a somewhat similar aspect. These objects hold an intermediate position, to our sight, between the more conspicuous groups in which bright stars, though evidently connected, are sprinkled pretty widely over the telescopic field, and the nebulæ, more properly so called, whose stellar nature, where it is distinguishable at all, is only developed by the most powerful instruments and under the most favourable circumstances. The term "nebula" in fact has undergone a process of retrogradation during the advance of science. In the ancient catalogues, "stella nebulosa" signified merely the misty aspect sometimes presented to the naked eye by a group of a few minute and indistinctly-seen stars—such, for instance, as that in the head of Orion—while, strange to say, some real and conspicuous nebulæ, those in the sword of Orion and the girdle of Andromeda, were entirely ignored. The introduction of the telescope, by exhibiting at once the composition of these specks, naturally displaced the

term, and fixed it on a much more numerous class of groups and assemblages visible only with its aid, and from the inadequacy of that aid presenting a hazy appearance. The increase of optical power in resolving the easier of these into open clusters, drove the term still further back into the depths of space; and now, though many of the ancient "nebulæ" of Messier's catalogue in 1783, like the lunar "seas," are indulged in common parlance by the retention of their antiquated title, in a more accurate classification they would be rated merely as "telescopic clusters," while the term "nebula" would be appropriated to objects which, even when examined with all the appliances of modern optical skill, are still characterized by a truly nebulous or cloudy indistinctness of aspect. These latter, indeed, belong to at least two perfectly dissimilar classes; and if the spectroscope could ever be rendered delicate enough to deal with all that the telescope can show, they would be ranked according to their true nature, the "continuous spectrum," or uninterrupted prismatic image, indicating the presence of stars so remote as to be separately undistinguishable, as the "gaseous spectrum," or image in which only a few bright bands appear, denotes that vaporous state to which alone in strictness the term "nebula" corresponds. At present, however, the latter name is indiscriminately given to every object whose hazy indistinctness conceals its real character. Between these and the more or less scattered groups, which, interesting and beautiful as they may be in the telescope, possess little definiteness of arrangement, intervenes the class of "globular clusters." They are not, indeed, marked off by any sharp boundary, especially on the hither side; the scattered sprinkle passing through a progressive series imperceptibly into the symmetrical cluster. But there is, nevertheless, as in many similar cases, quite sufficient individuality to constitute a separate order, though it is not easy to fix its precise beginning. Of these Sir J. Herschel has enumerated 111 in his "General Catalogue of Nebulæ and Clusters of Stars," published in the Philosophical Transactions for 1864—a noble work, which is never likely to be superseded, although, of course, the great Melbourne reflector and similar instruments may be expected to add to its contents. And it is on some of the peculiar characteristics of such clusters that we are going to offer a few remarks.

To the careless observer there may be little that is attractive in the first sight of a globular cluster in an ordinary telescope—a spot of dull foggy light, or at best a collection of minute and insignificant stars. But spectators of this class are not needed;

science can well dispense with them; their absence will never be felt at the eye-piece, unless, indeed, they come, as some of them may, to be awakened to more genuine curiosity and more earnest thought. To the attentive and intelligent eye, these misty specks or sparkling patches will disclose scenes of ever-increasing wonder, and for those who have access to instruments of varied aperture and power, it offers an interesting and instructive comparison to follow one of these clusters in its progressive "resolution," or separation into its component individuals. We may make choice for this purpose of one of the finest of them, that formerly called "the nebula in *Hercules*," No. 13 of Messier's Catalogue, commonly abbreviated into M 13, or 4230 of the "General Catalogue." This is easily found by drawing a line from *Wega* to *Gemma*, the brilliant in the Northern Crown; somewhat nearer to the latter than the former star this line will pass between two 3 mag. stars lying in a sloping direction at some distance on either side of it, ζ *Herculis* (the brighter) below, and η above; in a line between these two, but about one-third of the distance from η, the cluster is situated. Halley, who was the discoverer in 1714, says of it, "This is but a little patch, but it shows itself to the naked eye when the sky is serene and the moon absent." Thus seen, however, it will be too minute to give any idea of its nature. Direct to it the smallest telescope, even an ordinary finder, and it will be drawn out into a foggy speck; 2 or $2\frac{1}{2}$ inches of aperture will render it a conspicuous object; with about 4 inches the lower powers will show a beautiful lucid "ball of wool," brightening towards the centre, while higher magnifying will readily give twinkling points in the mass, that at once declare its character. Larger apertures will gradually bring more and more stars out of the cloud, and show it surrounded by a retinue of straggling attendants or "outliers," as they are termed; but the interior, though sparkling, and obviously starry, will remain condensed into such a "blaze," or continuity of light, as still (in connection with an interspersed multitude of the minutest points) to convey the impression of nebulosity; till, in the grasp of the largest reflectors, all remaining indistinctness is dissipated, the resolution is entire, the confusion of the crowd is pierced through, and the individuals stand insulated, in their countless thousands, upon the darkness of the heavens.

This, however, is one of the most favourable instances. In many others the process is less complete; we have to begin with an object undiscoverable by the naked eye, and leave it still imperfectly resolved with our utmost power, though its sparkling

or "granulated" aspect admits of no doubt that the deficiency lies merely in our instrument. Throughout the whole series, with a general uniformity of composition, we shall meet with abundance of individual diversity. In some cases the components are less crowded, and therefore of easier resolution; in others, though they may be separately brighter, and, so far, more distinguishable, they form, from apparent contiguity, a more intractable central blaze, or possibly a kind of nucleus—a phenomenon not unknown even in nebulæ of otherwise very feeble luminosity: the varieties, in short, of aspect are too numerous to be particularly described; the selection, however, of a few prominent characteristics may be of some interest to the reader, and more especially to the student who intends to make personal acquaintance with these strange occupants of distant space.

First, then, we shall draw attention to their *insulation*. This is not an invariable distinction of clusters, many of them seeming to be aggregations of thickly crowded strata of stars, such, for example, as constitute the ground of the Milky Way, round local centres of attraction. A very fine instance of one of these galaxy clusters is H VII. 12 (that is, No. 12 in Sir W. Herschel's 7th class), R. A. 7h. 12m. D. S. 15° 24′, in *Canis Major*, easily found a little more than 3° *f* γ, 4 mag.—the more easterly of the two tolerably bright attendants between which *Sirius* stands. Another, H VI. 30, R.A., 23h. 51m. D. N. 56°, in *Cassiopea*, is a splendid mass as viewed with a large aperture; lying about 2½° S. of β (the westernmost star of the great W) and somewhat *p*. Neither of these is classed as a globular cluster in the "General Catalogue," in which they stand 1512 and 5031, but they are mentioned here both as beautiful objects for the student, and as exemplifications of the fact that local concentration is occasionally to be met with in extended strata. Such, indeed, Sir John Herschel tells us, is especially the case even with regular globular clusters in a portion of the galaxy traversing the constellations *Sagittarius*, *Scorpio*, *Telescopium*, and *Ara*, and, though of course some instances might be due to mere optical superposition, yet in others he sees strong evidence of actual connection. But in that northern hemisphere with which we are more familiar, insulation is the general rule; though we shall not find in our own skies so striking an instance of it as that of the southern 47 *Toucani*, "a most glorious globular cluster . . . . a stupendous object," according to Sir J. Herschel, which, he says, is *completely insulated*, so that after it has passed through the field, "the ground of the sky is perfectly black throughout the

whole breadth of the sweep." This splendid mass, measuring with the stragglers 15′ or more, is so visible to the naked eye that Humboldt, on his arrival in Peru, mistook it during several evenings for a comet. In this imposing way these clusters stand out by themselves—distinct and separate families, or rather tribes, of hundreds and thousands of individuals, all so drawn into a compacted mass, that the bond of union on the one hand, and the segregation from the rest of the universe on the other, are obvious at a glance. There is something marvellously strange in the aspect of such a glittering ball—an island in the unmeasurable ocean of space; and not less remarkable, doubtless, must be its unknown destiny in the counsels of the Creator.

The numbers, again, thus gathered into one separate mass are even more surprising than their disconnection from other systems. Arago may have exceeded the truth in estimating them in some instances at as many as 20,000; and the first impression of extreme number is often a deception, which the process of counting, when practicable, dispels. But Sir J. Herschel, a witness of the most enlarged experience and unimpeachable accuracy, assures us that "on a rough calculation, grounded on the apparent intervals between them at the borders, and the angular diameter of the whole group, it would appear that many clusters of this description must contain at least 5000 stars, compacted and wedged together in a round space whose angular diameter does not exceed 8 or 10 minutes."

The insulation, of which we have spoken, does not, however, imply a definite boundary. On the contrary, these clusters are usually, as has been said, environed by a straggling retinue, whose relation to the interior mass in point of magnitude and position is sufficiently marked to preclude the idea of mere optical coincidence. One cluster in the S. hemisphere (Gen. Cat. 4372) is mentioned as having a scattered train extending all round to three times its diameter, and dying away very gradually.—This external diffusion is balanced, on the other hand, by a varying but usually considerable degree of central compression. It is obvious that if the components are arranged at equal distances throughout, the interior must on optical grounds appear more thronged than the edges, and this no doubt may sometimes be the sole cause of the brightening there. As Arago has, however, observed, such a constitution would produce a rapid dilution at the circumference, and a very slow increase towards the centre; while the ordinary aspect, being the reverse of this, indicates an actual and not merely an optical com-

pression. This, in fact, is in many instances so rapid and dense that unless the magnitude of the components is augmented, their mutual distances must diminish, towards the heart of the mass. That the latter is the preferable explanation of cases of irresolvable "blaze" is rendered probable by the corresponding appearance of resolvable ones when the power is insufficient to break them up. The increase of density is sometimes so rapid in a limited space as to give the impression of an actual brilliant nucleus of some kind, which nevertheless is probably, as far as starry clusters are concerned, an optical illusion, though in gaseous nebulæ it may be otherwise. In fact, these clusters are almost universally characterized by the absence of any very rapid inequality of associated magnitude. There is among them not only a wide range of magnitudes, where pretty equal, from about the 10th (M. 12. Gen. Cat. 4238, R. A. 16h. 40m. D. S. 1° 42′ in *Ophiuchus*) to the 18th (Gen. Cat. 4332, R. A. 17h. 41m. D. S. 37°) of H. (Sir J. Herschel)'s scale, or 9th to 11th mag. of Σ(W. Struve)'s; but also in individual clusters, as in the great cluster in *Hercules*, from the 11th to the 20th, that is, the smallest visible in an 18¼-inch front-view reflector. But anything like a sudden *jump*, if we may so express it, from comparatively great to very feeble luminosity is quite exceptional.

Two very interesting cases, indeed, of this nature deserve to be mentioned, though neither of them globular clusters, nor within European vision. One close group (4746 of H.'s Double Stars in Cape Observations) of 1½′ diam. consists of an 8 mag. star surrounded by a dozen of 12 or 13 m.: another group (4962) is composed of a 6½ m. star with 15 or 20 stars of 13 m. clustering round it. We may also allude to the marvellous instance of M. 80 (Gen. Cat. 4173), R. A. 16h. 9m. D. S. 22° 40′ in *Scorpio*, described by H. as a magnificent very bright large globular cluster, very much brighter in the middle, well resolved into stars 14 m.,—nearly in the centre of which a star of 6½ or 7 m. very suddenly appeared between May 18 and 21, 1860, and had almost faded by June 10. But this was probably a case of mere optical coincidence; and the previous two might possibly be nothing more.

As a rule, then, the democratic rather than monarchical constitution of these starry nations is evident. Not that, any more than in terrestrial states, real equality is often met with. H., indeed, at the Cape, occasionally came across clusters, and some globular ones, in which the magnitudes were remarkably equable; but a gradual subordination of several ranks is customary, and in some instances

it is carried out in a very singular way. We may take for an example the cluster in the S. hemisphere known as *ω Centauri*, "very conspicuous to the naked eye as a dim cometic-looking star," 4 or 5 m.—a "truly astonishing object," of which the great observer has given a beautiful and surprising representation. In this cluster, "beyond all comparison the richest and largest object of the kind in the heavens," and having a diameter of full 20′ or $\frac{2}{3}$ that of the moon, "there must be thousands of stars:" near the centre there are two distinct darkish spaces. The resolution with H.'s reflector was complete into stars of two mags., 12 and 13, "without greater or less, and the larger stars form rings like lace-work on it." He subsequently says, from a great many inspections, that he inclines to attribute the appearance of two sizes to little groups and knots of stars of the smaller size, lying so nearly in the same visual line as to run together by the aberrations of the eye and telescope, and not to a real inequality; and this explanation of an appearance often noticed in such clusters is corroborated in this instance by the distribution of these apparently larger stars in rings or mesh-like patterns, chiefly about the centre where the stars are most crowded.

These expressions seem to admit that the explanation is not universally applicable; and it certainly does not adequately meet such instances as M 13, containing a wide range of magnitudes, or others recorded by the great observer of the southern sky; such as M 22 (G. C. 4424), R. A. 18h. 28m., D. S. 24°, in *Sagittarius*, where 12m. stars are equally scattered over the cluster, but those of 20m. form the central mass:—Cape 3692 (G. C. 4311), "very much compressed in the middle, where, however, the stars are very small, while everywhere else they are 13 m."—Cape 3778 (G. C. 4467) "the stars are of 2 mags., the larger 11 m. run out in lines like crooked radii: the smaller, 16 m., are massed together in and round the middle." And a similar structure may be perceived in the grand clusters of our own hemisphere, M 3 (G. C. 3636) in *Canes Venatici*, M 5 (G. C. 4083) in *Libra*, and M 53 (G. C. 3453) in *Coma Berenices*. The following is a description of the working of a beautiful $9\frac{1}{3}$-inch silvered mirror upon the first of these. "Finely resolved: stars of 2 mags. at least; larger perhaps 9·5 Σ; smaller 10·5. The larger are sprinkled alike through the mass and among the outliers to the very edge. No central blaze, nor increase incompatible with a denser spherical form within a globe of more sparse and irregular character."

Some very remarkable examples may be given of peculiar internal arrangement. H. especially instances 47 *Toucani*, the "most glorious globular cluster" already referred to, as exhibiting "con-

densation in three distinct stages—first very gradually, next pretty suddenly, and finally very suddenly very much brighter in the middle up to a central blaze, ... the stars are all nearly equal (12 . . . 14m.)." But what renders this rapid internal compression the more remarkable is the "rose-coloured light of the interior, and the white of the exterior portions," a fact of which the great observer had no doubt. This singular contrast bears a considerable analogy with another fact pointed out by him, that among irregular clusters, exhibiting no central condensation, "it is no uncommon thing to find a very red star, much brighter than the rest, occupying a conspicuous situation." The stars in globular clusters are usually so minute, that such a distinction of hue would not be perceptible there, or possibly it might be found to be of more frequent and, in proportion, more significant occurrence. A somewhat parallel instance is Cape 3334 (G. C. 2354), which was at first taken to be a red star 10m. in the centre of an excessively condensed group 15 . . . 18m. with a surrounding nebulosity, but which was subsequently pronounced to be, not a star, but perhaps the centre of a very suddenly condensed globular cluster. It is deserving of notice that Secchi often observed a larger and redder star in the centre of the radiating groups, or at the commencement of the spiral arcs, which he found so prevalent among the larger stars in the galaxy.

The mention of these spiral arcs leads us to remark a similar arrangement in the structure of clusters. We have already had an instance in the "crooked radii" of Cape 3778: and H describes M 53 as having "curved appendages, like the short claws of a crab, running out from the main body;" and the great M 13 as having "hairy-looking curvilinear branches." It appears a strange and unaccountable relation that this curved formation should be perfectly similar to that of many gaseous nebulæ, which seem to have so very little in common with these masses of stars. In another particular, however, they may be thought to agree—a tendency to rifts, or linear vacancies. Those discovered by Bond in the Great Nebula of *Andromeda*, and fairly visible with 8 inches of silvered glass, are well known on the one hand; on the other, a parallel may be traced in the "dark lanes" detected by Lord Rosse in the great cluster in *Hercules*.

These remarks might have been easily extended. No notice has been taken of the inquiries that might have been instituted as to their conjectural magnitude and distance, the permanency of their constitution, or the somewhat mysterious indications of spectrum analysis. These may possibly furnish us with subjects of thought at some future opportunity.

THE LICHNOPHORA—MIMETIC INFUSORIA.*

BY PROF. ED. CLAPAREDE.

Stein has recently separated from the Vorticellina, under the name of Urceolarians, a family of ciliated infusorians, of which he distinguishes three species: *Trichodina*, Chr., *Trichodinopsis*, Clprd. and Lachm., and *Urceolaria*, St. This last genus contains only one species, previously described under the name of *Trichodina mitra*, St., a species for which Stein revived the name *Urceolaria*, already employed by Lamarck and Dujardin for Trichodina and certain other Infusoria. The convenience of erecting the Trichodina into a family apart from the Vorticellians, appears to me indisputable. It is, however, another thing to decide whether the Urceolarian family, as defined by Stein, is natural. The extreme affinity of the genera *Trichodina*, Ehrb., and *Urceolaria*, St., is evident; but the relationship of *Trichodinopsis*, Clpd. and Lachm., with these two genera is open to dispute. Stein observes that Trichodinopsis, with an almost complete clothing of cilia, cannot remain in the smooth family of the Vorticellians, as a ciliated Vorticellian would be a contradiction. In this he is right; but why should not a ciliated Trichodinian be also a contradiction?

The differences between Trichodina and the Trichodinopsis are great. The conformation of the oral row of cilia, that of the œsophagus, the position of the nucleus, are all differential characters in addition to those of the cuticle, which conveniently separate the the two genera. On the other hand, their resemblance is undeniable. It strikes the eye at the first glance, as it relates to the general form of the body and the sucker of the posterior extremity.

But while the resemblance is confined to superficial characters, the divergences result from profound differences in organization. Even after the deep researches of Prof. H. James Clark, which tend to separate still further the Trichodina from the Vorticellians, I find their affinities greater than those between Trichodina and Trichodinopsis. If it were not for the presence of the organ of fixation and locomotion, no one would think of associating Trichodina with Trichodinopsis. Doubtless it would be said that the presence of this organ in the two cases justifies their approximation. But have we not here one of those remarkable superficial resemblances which Mr. Wallace, Mr. Bates, and others,

* Translated from M. Claparède's paper in the "Annales des Sciences Naturelles," for which we have to thank the Author.

have made us acquainted with under the name of mimetic or mocking species?

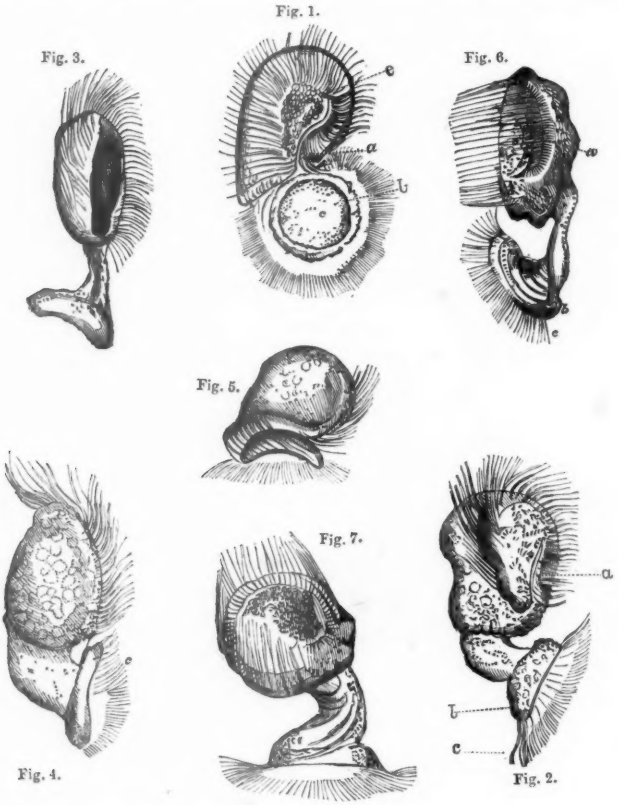
The discovery of ciliated Infusoria entirely different from Trichodina and Trichodinopsis, but, like them, furnished with an adhesive sucker, singularly corroborates this opinion. These creatures, to which I have given the generic name Lichnophora, or Fan-carriers, are not, however, quite new. Cohn had already noticed one species —doubtless identical with one which I describe below—during a visit to Heligoland, and described it *Trichodina Auerbachii*.

The two species of Lichnophora which I met with are from 0·05mm. to 0·06mm. long. I found them in Naples. One of them lived in great abundance on *Thysanozoon tubercula* (*Planaria tuberculata*, Della Chiaje, *Thysanozoon Diessingii*, Grube), the other inhabited the branchiæ of *Psygmobranchus protensus*, Phil. The first is, without doubt, identical with the *Trichodina Auerbachii*, Cohn, which the Prussian naturalist saw on a doris in Heligoland. This must, therefore, be known as *Lichnophora Auerbachii*. The second one I shall call *Lichnophora Cohnii*.

The resemblance between Lichnophora and Trichodina is so strong at first sight, that the confusion of the two, in spite of their essential differences, is very intelligible. I was at first deceived as well as M. Cohn. The body is composed of two fleshy portions—one the body, properly so called, and the other the anchoring sucker, united to each other by a sort of peduncle more or less compressed. The anchoring sucker turns its concavity towards the surface of the body of the part on which the Lichnophora lives as a parasite. It is to this fact chiefly and almost exclusively that the resemblance to Trichodina is referable; but the resemblance is only superficial. The sucker, Fig. 1, *b*, is bordered by a circular fleshy curtain, from which springs a very delicate membraneous ring, the laciniated border of which is prolonged into a circle of long vibratile cilia. The undulations by which the Lichnophora moves extend from the membrane to the cilia which form its continuation. The membraneous ring and wreath are not distinct like those of Trichodina. There is no trace of that characteristic solid ring which forms, so to speak, the skeleton of the organ of fixation of the Trichodines, Urceolarians, and Trichodinopsis.

The anterior part of the body is very difficult to study. It oscillates in different directions on its fleshy peduncle, and it is in vain to try to fix the creature by any chemical or mechanical means; for at the slightest lesion it suffers diffluence with lightning-like rapidity, and nothing but a chaotic mass of granules remains

under the eye of the observer. The anterior region, variable in form, is in general ovoid and truncated by a more or less flattened or concave peristome. Here the analogy with the Trichodines completely vanishes. Among these Infusoria, as among the Vorticellians, the peristome bears a row of mouth cilia, which make a right-handed spiral, the cilia striking in a direction opposite to that



of the hands of a watch. Here, on the contrary, the curve is left-handed, and the ciliary movement is like that of the watch hands. In the *Lichnophora Auerbachii*, the form of the peristome has scarcely any resemblance to the peristome of the Trichodines. At those rare moments when the animal turns its ventral face towards the observer, it is easy to see that the peristome is piriform, or rather rod-shaped (*virgulaire*) Fig. 1, *e*. The mouth, Fig. 1, *a*, Fig.

2, *a*, exhibits itself under the form of a slit, bent towards the left margin. The œsophagus is wanting, or of extreme shortness.

The *Lichnophora Cohnii*, Fig. 6, has a much larger peristome than *Auerbachii*. The shape appeared to me almost circular. I am not quite sure of the form of the buccal opening. Its peduncle is much more flattened, and ornamented with transverse arched rays, with their concavity turned towards the top. Perhaps it would be convenient to regard these two forms as varieties of the same species.

The fleshy peduncle does not at all resemble that of the Vorticellids. It is capable of being curved in opposite directions; but exhibits nothing like a muscle. Food does not penetrate into its interior.

This description is very incomplete. The reader will learn from it nothing about the nucleus, or contractile vesicle, notwithstanding I took some pains to discover them. One fact has been acquired for science: the Lichnophora are what the English call a mocking form of Trichodina; but they can scarcely be united to the family of Urceolarians. Their peristome reminds us more of that of certain Stylonichians, that is to say, of hypotrichal Infusoria, rather of the peritrichal forms. The sucker is an organ we meet with amongst epizootic Infusoria of very variable organization.

DESCRIPTION OF FIGURES.

Fig. 1.—*Lichnophora Auerbachii*, ventral surface.
Fig. 2. „ „ right hand and ventral view.
Fig. 3. „ „ „ and oblique.
Fig. 4. „ „ right side.
Fig. 5. „ „ front view; the peristome brought against the sucker.
Fig. 6.—*L. Cohnii* seen obliquely on the right side; *a*, mouth, *b*, sucker, *c*, ciliary membrane.
Fig. 7. „ „ front view.

ASTRONOMICAL NOTES FOR JULY.

BY W. T. LYNN, B.A., F.R.A.S.

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MERCURY, being in inferior conjunction with the Sun on the morning of the 14th, will not be well situated for observation in any part of the month of July.

VENUS is also in inferior conjunction with the Sun on the afternoon of the 16th. She will therefore gradually cease to be visible in the evenings; setting, on the first day of the month, at 9h. 14m., or a little less than an hour after the Sun, and, on the twelfth day, at 8h. 11m., or just at sunset. Her place at the beginning of the month is in the constellation Cancer.

MARS rises by the end of the month shortly after midnight. In the autumn he will become extremely well situated for observation, which he will well repay. We shall recur to this when the proper time arrives.

JUPITER becomes now a conspicuous object late in the evening. At the beginning of the month he rises about half-past 11 o'clock, at the end of it a little before 10. He will be, throughout, within two or three degrees (nearly to the south) of ϵ Piscium, a star of the fourth magnitude. On the morning of the 12th he is in conjunction with the Moon, then approaching her last quarter.

The appearance of Jupiter and his belts is familiar to all who are in the habit of using a telescope. With a general similarity, being always arranged more or less completely in streaks parallel to the planet's equator, they are subject to considerable changes, taking place with more or less rapidity. There is little doubt that they are in fact tracts of clear sky produced in the atmosphere of Jupiter by currents similar to those which cause the trade winds in our own. Their greater steadiness is due to the greater velocity of Jupiter's axial rotation, which is accomplished, as is well known, in the short space of about 9h. 55m. 30s. Our knowledge of this is derived from the motions of spots, which first led to a result of this kind in the hands of Cassini, *anno* 1665. The more usual colour of these spots is very dark; but much more recently some remarkable white or luminous spots, very small in size, have been seen. They were first observed by Dawes in 1849, and afterwards by Lassell in 1850; but are out of the reach of ordinary telescopes. All the phenomena appear to indicate an atmosphere in Jupiter of some considerable density.

We have this month to mention a few phenomena of Jupiter's satellites, which are frequently both interesting and useful. We

only, however, give those, in accordance with our usual plan, which occur within a short time of midnight. It is necessary to warn intending observers that the times given for the third, and still more of the fourth satellite, may be several minutes in error, their tables requiring considerable improvement. It is desirable, therefore, in observing them, to begin to look nearly ten minutes before the time assigned in the Nautical Almanac; but the times for the first and second satellite will usually be found to agree closely with observation. In observing a transit (that is, the beginning or end of the passage of a satellite in front of Jupiter), or an occultation, (that is, the beginning or end of the passage of a satellite behind Jupiter), the times of both the internal and external contacts of the planet and satellite, and also when the limb of the former appears to bisect the satellite, should, if possible, be recorded. But with all care it is difficult to determine the time of ingress or egress nearer than about half a minute even with a good telescope, without which such an observation can scarcely be made satisfactorily at all. The immersion of a satellite in the shadow of the planet (in the following table called its Eclipse—disappearance), and the emersion of a satellite out of the shadow (Eclipse—reappearance), may, however, be observed to a much greater degree of accuracy and with comparatively inferior instruments. As the shadow gives no evidence of its existence in the sky, it is, of course, necessary to know the approximate distance from Jupiter at which the disappearance or reappearance will take place. These are given for the cases which occur, at the end of the table.

DATE.	SATELLITE.	PHENOMENON.	MEAN TIME.
			h. m.
July 5.....	III.....	Occultation, disappearance ...	12 35
„ 6.....	II.....	Occultation, reappearance.....	12 23
„ 13.....	II.....	Eclipse, reappearance	12 11
„ 13.....	II.....	Occultation, disappearance ...	12 28
„ 16.....	I.....	Eclipse, disappearance	12 14
„ 20.....	II.....	Eclipse, disappearance	12 16
„ 22.....	II.....	Transit, egress	11 37
„ 24.....	I.....	Transit, ingress	12 47
„ 25.....	I.....	Occultation, reappearance.....	12 8
„ 29.....	II.....	Transit, ingress	11 38

The second satellite will, at the eclipse on July 20, disappear about one diameter of Jupiter to the left of the planet, as seen in an inverting telescope, and reappear after the eclipse on July 13, within a very small distance of him, also on the left side; the first satellite will disappear in the shadow on July 16, about half a diameter of the planet distant from him—of course on the same side to which the shadow is directed before opposition. At that time the reappearance of this satellite is never visible, as it takes place when the satellite is behind Jupiter.

The relative appearances and colours of the satellites at different times are well worthy of observation, as they are subject to various changes of appearance and fluctuations of brightness. From these it has been concluded that, like our Moon, they always present the same face to their primary. And, notwithstanding bold assertions made in some quarters to the contrary, we must maintain that this, if established, proves that they, *like her*, have axial rotations, the times of which are equal to those of their sidereal revolutions around him. These times are 1·8, 3·6, 7·2, and 16·7 days respectively. The third satellite is considerably the largest, and is, usually, the brightest. It has been a good deal discussed whether Jupiter's moons are visible to the naked eye. This is not usually the case, but there appear to be authentic instances of their having been so seen, especially when several satellites have been on the same side of Jupiter, and near together.

The planet SATURN continues to be visible during the whole evening throughout the month of July. At the commencement of it, he sets about half-past one in the morning; by the end of it, a little before midnight. In configuration, he will form nearly an isosceles triangle with β Scorpii and λ Libræ, stars of the second and fourth magnitudes respectively, being less than two degrees to the north of a line connecting them. He will be in conjunction with the Moon on the morning of the 28th, she being then a little past her first quarter.

OCCULTATIONS.—We have to call attention this month to one occultation only of a star by the Moon—that of the bright star Aldebaran early in the afternoon of July 16. The times of disappearance and reappearance are 2h. 29m. and 2h. 51m.; the angles from the vertex at each (reckoned, as usual, to the right in an inverting telescope) 202° and 249° respectively. As the Moon does not set until twenty-four minutes past four, and the star is well adapted for visibility in daylight, the observation may probably be made without much difficulty by the aid of an instrument of

good power, and will well repay the attempt if the weather is favourable.

ENCKE'S COMET.—Throughout this month, this small but interesting body will be approaching both the Sun and Earth. On July 1st, it will be distant from us by exactly twice the distance of the Sun; on July 31st, by only one and a half times that distance. Until the middle of the month, its place in the heavens will be in the constellation Taurus; in the latter part of it, in Auriga. During the whole time, it will not rise until shortly after midnight; nevertheless we proceed to give a few approximate places of it, according to the calculations of Becker and von Asten, here reduced to Greenwich midnight.

DATE.			RIGHT ASCENSION.			NORTH POLAR DISTANCE.	
	d.	h.	h.	m.	s.	°	′
July	1	12	3	17	26	64	2
„	6	12	3	34	5	62	50
2 „	11	12	3	5	27	61	40
2 „	16	12	4	1	47	60	33
5 „	21	12	4	3	26	59	35
0 „	26	12	5	1	44	58	46
„	31	12	5	29	0	58	14

BRORSEN'S COMET.—We have a few words again to say with regard to this little comet also, but they are exclusively of an historical nature, as further observation of it during this return is now out of the question. It appears that Professor Bruhns was *not* the first person to detect the comet at the late appearance, as we stated last month. Schmidt at Athens and Tempel at Marseilles, both saw and observed it on April 11th, one day before Bruhns. Tempel believes, indeed, that he *saw* it as early as March 22, but was not able to obtain even an approximate position of it until the 11th of the following month. These facts he communicated in a letter to Professor Bruhns.* Schmidt, the indefatigable Director of the Observatory at Athens, obtained a series of equatoreal observations of the comet, commencing on April 11, and Bruhns, with the aid of his assistants, Engelmann and Vögel, also obtained one at Leipzig, commencing on April 12. It was

* "Astronomische Nachrichten," No. 1692.

afterwards observed at various places, both in England and on the continent, and results arrived at which are not yet fully made known.

The observations of Professor D'Arrest, however, at Copenhagen, possess some points of especial interest, particularly as he observed the comet also at both its previous appearances, in the years 1846 and 1857. He has succeeded in obtaining a good series, commencing on the 2nd of May (the weather previously having been unfavourable), and we here translate part of his remarks from No. 1697 of the "Astronomische Nachrichten." In a letter dated May 14th, he says: "The very strong condensation towards the centre, and the three or four bright points, which, in the want of a proper nucleus, have now, as is believed, been seen around the centre in the first month after the perihelion passage, are in good agreement with our remarks on former occasions concerning this comet; as is also the very small tail-like lengthening which has been thought to have been noticed in the comet-seeker. In the refractor, as at the preceding appearances, neither tail nor proper nucleus have been visible. The total brightness of the centre I found on May 2, 1868, to be equal to a star of the 8-9th magnitude, and on May 13th scarcely any decrease in this was to be perceived. I have not the impression that any diminution in the amount of light given by this comet can be proved to have taken place during the few years which have elapsed since 1846. In the year 1857, I was surprised at its unexpectedly great brightness; at the time when it was most conspicuous, its centre was comparable to a star of the 6-7th magnitude. It was easily visible even with small instruments in strong twilight and whilst the Moon was full. Nay, Schmidt thought that he saw it repeatedly with the naked eye between the 8th and 20th of April. This year the comet has not indeed at any time attained nearly the same degree of brightness; but the intensity would really be somewhat less, on account of the greater distance, than in the middle of April, 1857. During the next few weeks it will be very interesting to watch the remarkably rapid diminution of the comet's brightness, which astonished us in 1846 and 1857, and which will begin to be perceptible at the beginning of June. According to the experiences obtained at former appearances, I can scarcely consider it probable that it will be possible anywhere to follow it up to the beginning of the month of August."

In a subsequent letter, dated May 23rd, D'Arrest says that the diminution in the amount of light was then already perceptible, whilst the apparent size had evidently increased. On the 17th, he observed it occulting a star of the seventh magnitude. The ap-

pearance presented by the comet and star was similar to that of a very fine nebulous star of the fourth class.

NEW PLANET.—A 98th small planet was discovered by C. H. F. Peters, at Hamilton College, Clinton, U.S., on the 18th of April. It has received the name of Ianthe.

THE MOON.—On the 1st of the month, Copernicus and its neighbouring ranges may still be viewed with advantage, as the terminator will not have long passed over it. The Sinus Iridum, a level plain surrounded by abrupt and colossal cliffs, will also be well viewed near the Moon's north point. On the other side, the green Mare Humorum may be studied on the 2nd day, and the remarkable plain called Schickard on the 3rd. The Moon will be full at 8h. 39m. on the evening of the 4th. We would call attention to the row of craters which may be seen on the retreating terminator about the 6th. Commencing with near the western limb, and proceeding southerly, they are known as Langrenus, Vendelinus, Petavius, and Furnerius. Petavius, particularly, is a remarkably fine object. The Moon is in her last quarter on the 12th, 40 minutes after midnight, and new at 9h. 56m. on the evening of the 19th. About the 22nd the row of craters last mentioned may be again observed. On the 24th the lofty range Mount Taurus and the adjacent objects, particularly Mount Argæus (so named by Mr. Webb from that proximity), will be in view. The objects of the Mare Serenitatis call for examination about the 25th. The next day the Moon is in her first quarter at 1h. 52m. in the afternoon. For the 27th, we would call attention to the remarkable craters Clavius and Maginus, near the north point. Copernicus will be well viewed about the 29th. Euler, Helicon, etc., nearer the north point on the 30th. The same day, the well-known and brilliant crater, Archimedes, will be on the terminator.

We may conclude with the remark that July is not a month adapted for the observation of faint objects, or that is likely to be very fruitful in results for astronomy. The "empire of the night" is both short and doubtful. Nevertheless, there is always work to be done in a science of so large extent, and persevering devotion to particular points under various circumstances seldom fails to accomplish something of value. We would call the attention of observers of solar spots, and of the Sun generally, to the desirability of observing within two or three hours, if possible, of sunrise. But we fear that at this time of the year but few will care to undertake this. Those who do will find the definitions greatly superior to what they are later in the day.

PROGRESS OF INVENTION.

A METHOD OF MAKING SUGAR OUT OF JUICES, SYRUPS, AND MOLASSES.—The principle of this invention has been known for a long time, but its application and modification by M. le Play, of Paris, seems to be new and very promising. Sugar is precipitated as an insoluble compound of lime, and then set free. Instead of using barium, which is a very poisonous substance, M. le Play employs lime (the common hydrate). He first adds this to the liquid to be treated; he then adds chloride of calcium, and caustic potash, or soda. The precipitated sugar compound, containing sugar and lime, after being washed with water, is decomposed by carbonic acid, obtained in the preparation of the chloride of calcium, and by heating common chalk. If this last process is effected in a closed vessel, no stirring will be required. This method can be applied as well to the juice of beetroot as to syrups and molasses. Syrups, for instance, are treated as follows:—They are first diluted with an equal quantity of water, and then saturated with lime, the lime being in excess: this excess being a proof of saturation, causes a better precipitate of sugar with lime afterwards. Water is then added, and chloride of calcium in lumps or in solution; it must be stirred and heated. After the temperature has been raised to 100° C., caustic potash is added to the solution, which is stirred till it begins to boil. The precipitate is then formed, and, after being washed with water, it is decomposed with carbonic acid. Sugar can be obtained from the solution, and the mother liquid can be again treated in a similar manner for the recovery of more sugar. M. le Play says that the uncrystallizable sugar in molasses is destroyed by this method of treating with lime.

HIGH PRESSURE CALORIC MACHINE.—The various forms in which caloric machines have been produced have received an addition, in one invented by Richard Unger; it is one which well deserves attention. This machine, from its construction, does not require to be so large as those in general use; and by it, the difficulties hitherto arising from the high temperature required, are avoided. Charcoal is burned in a closed stove under a pressure of five atmospheres. The air required for its combustion is supplied by a pressure pump, worked by the machine. To the gases produced by the combustion of the charcoal, a quantity of air is brought at a temperature of about 30° C., by means of the above mentioned pressure pump; in this way a gas mixture is obtained of a temperature of from 250° C. to 300° C., which is the air used for working the machine. The engine drives a small water pump besides the pressure pump, the water from which serves to cool the air during its compression, and in this lies the special success of the machine; for by syringing cold water, in a fine spray, on the compression cylinder, it is possible to keep the air at a low temperature of about 30° C., which afterwards

becomes heated to 250° C., or 200° C., by mixing with the gases formed in the chamber where the charcoal is burnt, and so becomes considerably increased in volume, and in consequence acquires a corresponding amount of power for working the cylinder of the machine.

Optical Glasses.—Lead thallium glass has lately been made by melting 300 parts of pure sand, 200 parts of red lead, and 335 parts of carbonate of thallium (instead of 100 parts of carbonate of potash); it has a yellowish tint, a specific gravity of 4·235, and its index of refraction is 1·71.

Castors for Furniture.—The great defect under which the ordinary castors for furniture labour is that the axes of the wheels project beyond the legs of the tables or chairs to which they are attached, and by this means great strength is lost. Mr. Raymond Fletcher has, however, invented a castor which is not liable to this objection, and which has, moreover, the advantage of being ornamental. His invention consists of a spherical brass cup, the upper part of which is flanged, so that it can be screwed to a metal plate which is permanently fastened to the piece of furniture. A ball is made to play within this cup, the ball, of course, being smaller than the cup, so that it can move easily within it. The cup is not so deep as the ball, so that when it is screwed to the metal plate, the ball projects below it, and this ball acts as the support of the furniture, for it rests on the ground. Above the ball there are metal rollers working on axes, and these touch the upper surface of the ball, and allow it to revolve freely in all directions, they being so placed that their axes form an equilateral triangle. These bearing rollers may be either fitted to the cup on its inside or to the bearing-plate. Balls can be used instead of rollers. As a further improvement, the cup and bearing-plate can be made in one, the ball being put into the cup through an opening closed by an annular plate or ring for keeping the ball in position.

Manufacture of Sulphuric Acid.—Some important improvements in the manufacture of sulphuric acid have been patented in France. The principal recommendation of this patent is that all large leaden chambers are dispensed with. The sulphur or pyrites is burned in compressed air, and the sulphurous acid formed by this combustion is first purified from arsenic before it is brought into contact with nitrous acid. The chambers in which the oxidation of the sulphurous acid is effected are constructed in a very convenient and suitable manner.

A New Method of Treating Caoutchouc and other Gums.—Sulphur is boiled in turpentine or some similar oil, a solid residue remains, the oil is poured off from the precipitate, which is washed with dilute sulphuric acid, and dried at a low temperature. Iodine is then treated in a similar manner to the sulphur, sulphuric acid being added to prevent the formation of explosive compounds. The caoutchouc is then thoroughly incorporated with a mixture formed of equal parts of the sulphur and iodine

compounds, in the proportion of about three ounces of the composition to one pound of the gum, which can then be moulded into any desired form, after which it is to be placed in an oven and kept at a temperature which is gradually increased to 320° Fah., this temperature is to be maintained for five minutes, and is then to be quickly lowered to 250° Fah., at which it is to remain for about an hour or until the composition is hard. The substance can be tinted to any colour with earthy or mineral colours which are not changed by the hardening process. The product thus obtained is hard, tough, and durable, it is not affected by acids, and is applicable to many useful and ornamental purposes. Another method of treating india-rubber or gutta-percha consists in its immersion in bromine. After the gum is moulded or carved, it is placed in bromine, and kept there until, after exposure to the air, it becomes hard. By this process the character of the gum becomes changed; but in order to prevent it from hardening before it is taken out of the bromine, chloroform, or some other solvent, may be added to the bromine in the proportion of nine parts of the latter to one of chloroform. India-rubber or gutta-percha can be dissolved in this mixture, and the solution can be applied in successive layers to a mould on which any article is to be formed; or it can be applied as a coating to other materials, the gum hardening on the evaporation of the chloroform. The patentees of this invention are Messrs. J. B. Newbrough and E. Fagan, of New York.

Securing Watch-chains.—Messrs. William James and William Hill, of Birmingham, have patented the following invention for securing watch-chains. The invention consists of a metal plate, on one side of which is a hook-like shank; to the front side a ring is attached, either split or not, to which the chain is fastened. A hole is made in the waistcoat or other garment, through which the hook-like shank is passed; a plate of metal is then placed on the other side of the garment, and through a hole or slot in this plate the hook-like shank is passed; it is kept secure in this position by means of a small bent spring working on a pin at one end of it, which, when passed through the hook-like shank, holds the front plate in the desired position.

Obtaining Chemical Compounds.—To obtain chlorine, soda, potash, and phosphorus—and their compounds—in an improved and economical manner, Mr. James Anderson, of New Buildings, Londonderry, applies a very high temperature to the materials containing the substances required, in the presence of other substances necessary to bring about the reactions desired. This high temperature is applied by passing through the materials a gas, such as carbonic oxide or nitrogen, which contains no free oxygen. In one modification of this invention, there are introduced into a furnace, like a blast or smelting furnace, silica, alumina, or minerals, or rock containing them, such as flint, quartz, felspar, cryolite, gneiss, and the like, preference being given to those containing soda and potash. The minerals are to be broken small, so as to allow gases to pass through

them, and so as to expose a large surface to the action of these gases. A mixture of air and steam heated to a very high temperature by means of a regenerative furnace or other furnace, capable of giving the necessary heat, having first been passed over chloride of sodium or potassium, which it volatilizes and carries along with it, is made to enter the lower part of the furnace, and then to pass through the minerals. As the minerals become heated the chloride is decomposed, the sodium and potassium combining with the silica and alumina to form silicates or aluminates of sodium or potassium, which melt and flow out at the bottom of the furnace, whilst chlorine, steam, and nitrogen pass out at the top. The steam is condensed, and the chlorine may be separated from the nitrogen by absorption by lime; the silicates and aluminates are mixed with chalk, lime, or baryta as they flow out from the furnace. Hydrochloric acid may be obtained, if required, by passing through heated steam alone, instead of the mixed steam and air. The silicates and aluminates obtained in this manner are introduced into another similar furnace along with carbon, in the form of, for example, coal, coke, or charcoal; and a current of very highly-heated gas is made to enter at the lower part of the furnace, and to pass up through the materials. When the alkaline metals are required, the gas employed is carbonic oxide, or a similar gas; and when the materials obtain a sufficiently high temperature from the gas, they melt and percolate through the infusible charcoal. The alkaline earths replace the alkalies, and these being liberated are reduced by the carbon, and pass off in a volatile state, by an aperture or passage in the side of the furnace, along with the carbonic oxide formed and the heated gas introduced. When a cyanide is required, nitrogen is introduced into the furnace, and combines with the reduced alkaline metal and carbon, forming a cyanide of sodium or potassium, which passes off along with the carbonic oxide. When it is desired to get a phosphide, a phosphate such as tricalcic phosphate is introduced at the top of the furnace along with the other materials, and heated carbonic oxide is introduced below. The lime of the phosphate unites with the silica and alumina, and the trihydric phosphate liberated is reduced by the carbon at a high temperature, thus forming phosphorus and carbonic oxide, which pass off by a passage at the side of the furnace along with the alkaline metals, the phosphorus combining with them to form phosphides. Air may be used instead of pure carbonic oxide, provided that its oxygen be previously converted into that gas by well-known means, and when the formation of cyanides by the nitrogen of the air is not objectionable. When phosphorus is required, silica, alumina, and phosphate of lime are put into the furnace at the top along with carbon, and heated carbonic oxide is introduced at the bottom. The lime combines with the silica and alumina, and the phosphoric acid liberated is reduced by the carbon, and the phosphorus passes off along with the carbonic oxide and other gases introduced.

SEPARATING YEAST FROM LIQUID MATTERS.—This process consists in the employment of centrifugal force. A circular box is made, the periphery of which is made of wire gauze; within it is placed a linen or cloth bag containing the yeast, the box is made to revolve rapidly, and in this manner the moisture is thrown off.

BOX-IRONS.—Mr. John Whitehouse has invented a box-iron in which the opening is at the top; a lid is hinged to the front part of the iron case which holds the heater; the handle is, as usual, of wood; a metal guard is placed between it and the iron to protect the hand from the heat; to the heater an iron wire loop is fastened, by which it can be removed from the box; and its bottom surface is indented so that it only comes in contact with the box in places, and thus the heat is better regulated; and not radiating so rapidly, the conduction to the outer surface being less perfect, the iron will remain hot for a longer time.

COMBINED MUFF AND BAG.—A very convenient, secure, and not unsightly arrangement has just been brought out and patented by Moritz Vogl and Heiman Van Dyk. It consists of a frame with an upper and under part; the frame is curved to the shape of the muff, and is made of metal; it opens outwards somewhat like a purse. The fastening, or catch, which is attached to the upper part of the front frame, passes through the back part of the frame, and can be fastened or released inside the muff; and to it a lock can be attached, if desired. A spring is fixed between the front and back part of the frame, which causes it to fly open when the catch is released from the inside of the muff; and when it is desired to close the bag, it can be done by pressure from without. By properly arranging the hair of the muff, the bag may be entirely concealed.

LITERARY NOTICES.

RELIQUIÆ AQUITANICÆ; Being Contributions to the Archæology and Palæontology of Perigord, and the adjoining Provinces of Southern France. By Edouard Lartet and Henry Christy. Edited by Thomas Rupert Jones, Professor of Geology, etc., Royal Military College, Sandhurst. Part V. (Baillière.)—In the fifth part of this splendid work, Professor Rupert Jones concludes a sketch of the geology of the Vezère, and then follows an interesting letter from Mr. Alex. C. Anderson, of Vancouver's Island, showing the similarity of some of the implements found in Dordogne to those used by the North American Indians, and instituting comparisons between the cave dwellers and the ancient Germani, as described by Cæsar and Tacitus. Mr. Anderson makes the following observations on the reindeer, which may tend to correct some common misapprehensions.

"Reindeer have never, in America, been herded in a domestic state, as is done by the Laplanders and others of Northern Europe; nor are they by the natives employed as beasts of draught. They exist only in their wild and natural condition. . . . . So with the Germans, and so, inferentially, with the people of ancient Aquitania; for there is nothing to authorize the supposition that they (the Germans) *tamed* the reindeer for domestic purposes, but only hunted it. . . . . Indeed, I very much question whether the Laps, Fins, etc., *domesticated* the reindeer until a comparatively late date. . . . Any theory, therefore, that might be based upon the disappearance of the reindeer from southern latitudes, in connection with the migration northward in remote ages of the past of the Esquimaux and other northern tribes, ought, I submit, to be very cautiously entertained."

The part before us is illustrated with four plates representing varieties of flint implements, and two landscape views of the site of caverns, explored by Messrs. Lartet and Christy, one representing Le Moustier on the Vezères, and the other the village of Les Eyzies.

It is impossible to do justice to a work of this kind until it is completed, but there can be no doubt from the five parts now before the public, that it will be a record of great interest in a scientific point of view, and will be highly gratifying to the friends of the late Henry Christy as a noble monument of his intelligence and zeal.

Ovid, Selections for the Use of Schools, with Introduction and Notes, and an Appendix on the Roman Calendar. By William Ramsay, M.A., formerly Professor of Humanity in the University of Glasgow, Author of "Manual of Roman Antiquities," etc. Edited by George G. Ramsay, M.A., Trin. Coll., Oxon, Professor of Humanity in the University of Glasgow. (Oxford, Clarendon Press.)—This is an elegantly printed book of 352 pages, of which seventy-four are occupied with judicious selections from the poet, and the remainder with valuable and scholarlike notes, which will be found of much use to students, as they range over a great variety of topics, critical, philological, historical, mythological, etc.

Every Man's Own Lawyer; a Handy Book of the Principles of Law and Equity, comprising the Rights and Wrongs of Individuals. By a Barrister. Sixth Edition, carefully revised. (Lockwood and Co.)—This is a very useful work, which ought to find its way into all family libraries, merchants' counting-houses, etc. It is a compendious epitome of laws affecting the relations and transactions of ordinary life. It is well printed, of a handy size, and convenient for reference. The fact of this work having gone through five editions is evidence of its adaptability to general wants, and although we cannot endorse the promise on its cover, of "no more lawyer's bills," we very strongly recommend it as a serviceable guide, and frequent substitute for consultations.

First Lessons in Astronomy in Question and Answer. Seventh

Edition, revised. (Jackson, Walford, and Hodder.)—We cannot recommend this Catechism, as sufficient care has not been taken in re-editing it, and we do not think very highly of the catechism form of communicating knowledge. At page 8 is a curious mistake, that at seventy miles an hour it would take forty thousand years to go round the sun's circumference, which is given at 2,764,600 miles. In the chapter on the telescope it is erroneously stated that all the nebula examined by Lord Rosse's telescope have been resolved into stars, and that all nebula are star clusters. It is also absurd to represent our knowledge of the moon as having been materially effected by Lord Rosse's instrument, as all the principal moon work has been done with other instruments; nor is it right to assert that the whole surface of our satellite presents the appearance of a prodigious cinder, or a world entirely consumed by volcanic fires. Some folks have had such fancies, but they may be a long way from facts. The real constitution of the moon is still open to much doubt.

Instructions in Wood Carving for Amateurs, with Hints on Design. By a Lady. (Lockwood and Co.)—This is an elegant little book, which we hope will induce many of our readers to follow the good example of its authoress, and learn an art of much value and well adapted to female skill. In the present day, when in too many well-to-do families girls who have left school, pass their time in unprofitable idleness, it is well to find recreations springing up which tend to cultivate taste, and make the principles of design familiarly understood. With a little pains and patience ornaments of great beauty may be made upon the hints given in this book, and the knowledge gained will greatly facilitate the appreciation of the higher branches of design, as exhibited in architecture and art manufactures.

A Treatise on the Action of Vis Inertia in the Ocean; with Remarks on the Abstract Nature of the Forces of Vis Inertiæ and Gravitation, and a New Theory of the Tides. By Wm. Leighton Jordan, F.R.G.S. (Longmans).—We are afraid this must be catalogued amongst the long list of mistaken works, such as those which endeavour to demonstrate that the earth is a prolate, not an oblate, spheroid; that the orbits of celestial bodies are perfectly circular, etc., etc. Mr. Jordan considers that as the earth rotates, the vis inertiæ of the waters of the ocean give them a permanent tendency to a relative movement in an opposite direction. He seems to regard currents and tides as resulting from the conflict of terrestrial rotation with vis inertiæ; but we do not profess to understand his explanation. Perhaps our readers may succeed with such sentences as the following:—"As the earth moves, the force of gravitation, which is the act by which vis inertiæ resists that motion, is then created by the pre-existing force of vis inertiæ, simultaneously with the creation of the motion which vis inertiæ resists." Or, "In two volumes, published in 1866 and 1867, I have endeavoured to show that

not only the ocean, but also the outer crust of the earth and the atmosphere, all bear evidence of the action of vis inertiæ upon them; and if this be shown to be the case, we shall then have made the first inductive step towards a knowledge of the cause of the motions of the earth. For, if it be shown that those parts of the earth are acted upon by vis inertiæ, it must then be admitted, as a necessary corollary, that the forces which move the earth act chiefly upon it in its interior parts, so that the outer crust of the earth, as well as the ocean and air, being comparatively dead to the influences which cause motion, are acted upon by vis inertiæ as they are carried along upon matter in the interior part of the earth, which must be either comparatively alive to influences from without which set it in motion, or, otherwise, must move by virtue of an inherent property of motion which the exterior parts of the earth do not possess."

Om en Märklig i Nordsjön lefvande art af Spongia. Ap S. Lovén. This is a paper from the Transactions of the Stockholm Academy, describing a small but very interesting species of siliceous sponge of the genus Hyalonema. Our readers will recollect Professor Wyville Thomson's paper on the *H. Sieboldii* in the Intellectual Observer. Since then M. B. Du Bocage discovered a Portuguese species, *H. Lusitanicum*, and M. Lovén now describes "*H. boreale* n. Hab. in mari septenntrionali extras oras Norwegiæ profunditate 200 orgyarum." The paper is illustrated with engravings, representing the pear-shaped sponge supported by a column formed of a bundle of siliceous threads, showing details of structure.

Researches in Solar Physics. By Warren De la Rue, Esq., Ph. D., F.R.S., Pres. C.S., F.R.A.S.; Balfour Stewart, Esq., LL.D., F.H.S., F.R.A.S., Superintendent of the Kew Observatory; and Benjamin Loewy, Esq., F.R.A.S., Observer and Computer at the Kew Observatory. Appendix to Second Series, and in continuation of it. On the Distribution in Heliographic Latitude of the Sun Spots. Observed by Carrington. (Printed for private circulation by Taylor and Francis.)—In the second series of these important researches the authors observed, "it would appear that spots are nearest the equator when the heliographic latitude of Venus is 0°, and are most distant from the solar equator when this planet attains its greatest heliographic latitude." The present publication gives a mass of tabulated details to test this statement. The result is, that on the average the latitude of sun spots when Venus crosses the solar equator is less than when she is at her greatest distance therefrom; but this difference—between 16° 8′ and 17° 16′—is not as great as might have been expected from the theory of the influence of the planet; and the authors consider "more observations necessary." "At those periods for which the present method of research is particularly applicable, we get a good result; but for that period for which it is not so applicable the evidence is less satisfactory." It is to be hoped that further research will clear up this very interesting question.

NOTES AND MEMORANDA.

COURSE OF ATLANTIC STORMS TO ITALY.—M. Matteucci publishes in "Comptes Rendus" a short paper, showing that out of 118 storms coming from the Atlantic and striking the western coasts of England and Ireland, 49 reached Italy. In October, November, and December, the progress of these storms to Italy is much more frequent than at other periods; while in midwinter, and still more in summer, a striking diminution occurs. In the three months named, out of 29 storms, 23 reached Italy; in April, May, June, July, and August, out of 41, only 3 arrived at Italy.

PHOSPHORESCENCE OF THE SEA.—On the night of the 31st May, an unusually magnificent display of luminosity of the sea was witnessed at Teignmouth. A correspondent tells us that old sea-captains pronounced it the most brilliant they had ever seen. He says, "The waves broke moderately, from two to three feet high, of the most magnificent green that can be conceived—the new aniline green is nearest to it—and of such power that the light was visible against rocks two miles away." The same correspondent kindly sent us some of the luminous water, which we found full of the well-known *Noctiluca miliaris*.

ACTION OF SNAKE POISON.—Mr. S. P. Holford states in "Trans. Roy. Soc. of Victoria," that when a person is bitten by the Cobra di Capella, living germs are introduced into the blood, which multiply, so that millions of small cells are produced in a few hours, at the expense of the oxygen absorbed during respiration. He describes the cells as round, about 1—1700″ in diameter, and having round nuclei 1—2800″ in diameter, and containing germinal spherules.

CAPACITIES OF IDIOTS.—Some very interesting statistics are given in the schoolmaster's report of the state of his pupils in the Earlswood Asylum. He has 154 scholars from the inmates, and they are divided into six classes. The highest "can read in the New Testament with tolerable correctness, write sentences in copy-books, and do sums either by themselves or from the black board. The second class can read in an easy lesson-book, count above sixty, and add a little from the black board. The third class know the greater part of the alphabet, and count above thirty. The fourth class know six or seven letters, and count above twenty. The fifth can only speak vowel sounds, know one or two letters, and count to three or four. The sixth can only articulate one or two sounds, and cannot count, but will sometimes come when they are called."

STARCH IN THE YOLK OF EGG.—M. Dareste states in "Comptes Rendus" that he has succeeded in identifying with starch certain granules observable in the yolk of an egg.

THE OXYHYDROGEN LIGHT.—M. Caron states that oxide of zircon gives the most luminous effects on the oxyhydrogen flame. As it is expensive, he merely coats another material with it.

DEEP SEA DREDGING.—There is reason to hope that the government will place a suitable steamer at the disposal of Dr. Carpenter and Professor Wyville Thomson for some important experiments in deep sea dredging, which the Royal Society has had the good sense to support. In a letter to Dr. Carpenter, Professor Wyville Thomson alludes to the success obtained by M. Sars, the Swedish naturalist and inspector of fisheries, who obtained abundant animal forms at 300 fathoms depth off the Loffoden Isles; amongst them a beautiful little crinoid, at once recognized as a degraded type of the well-known fossil Apiocrinites. Dr. Carpenter addressed General Sabine, President of the Royal Society, on the subject, pointing out that the projected expedition could not be accomplished by private means. He proposes to start from Kirkwall or Lerevick, and to explore the sea bottom between the Shetland and Faroe Isles, dredging round the shores and fiords of the latter, and then to proceed N.W. into deep water. Results of great importance to science may be anticipated if this project is carried out.

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